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PRESIDENT'S MESSAGE--LOUISIANA DIVISION

Ronald Blanchard

Napoleonville, Louisiana

The Louisiana Sugar Industry's total sugar production was severely affected by the winter of 1983. Below freezing temperatures on December 24, 25 and 26, 1983, took their toll on the 1984 stubble crop. Low temperature readings of 13.5°F were taken at the USDA station in Houma and many temperatures of 9 and 10° were observed throughout the cane belt.

As farmers plowed out fields where it was apparent that very little cane had survived the freeze, mills became concerned about greatly reduced cane supply, and farmers began to worry about abnormal plantings. Most farmers were forced to keep fields that they felt would return only their variable cost and many fields of less than 10 tons per acre were kept. A reduction in total cane acreage from the 1983 crop of 13.2 percent was evidenced. The total cane acreage dropped from 265,000 acres in 1983 to 230,000 acres in 1984. This, coupled with a 20 percent increase in the acreage used for seed, reduced the total acreage of cane for milling from 245,000 to 205,000 acres, a reduction of 16.3 percent.

The keeping of weak stubble cane resulted in lower yields per acre and may have contributed to lower sugar recovery per gross ton as more soil and grass were brought to the mills from these low yielding fields. Yields per acre fell from 26.7 to 24.6 tons and recoveries from 185 pounds of sugar per ton to 180 pounds, resulted in a decline in the average sugar per acre from 4,947 pounds to 4,439 pounds, or a 10.3 percent decline.

The total 1984 sugar production was 455,000 tons, down from 606,000 tons in 1983 - a decline of 25 percent in total sugar from one year to the next. The 1984 crop was processed by 21 mills, with the first mill starting in mid October and last mill finishing prior to the end of the year. Some mills had a season of less than 30 days.

The 1984 crop was followed by a severe freeze on January 21 and 22, 1985, when temperatures again dropped to 13°F at the USDA Station in Houma, and 9 and 10° temperatures were reported throughout the belt. The full effect of the freeze on this crop will not be known until after the harvest, but many stubble stands appear to be adversely affected.

Most producers feel the crop could be slightly better than last year's, primarily due to increased cane acreage. Most producers also feel that last year's crop improved greatly in the latter parts of the season - mainly during August, September and October. Any comparative predictions to last year's crop, therefore, have to be made with extreme caution.

As the northern most cane producing area of the world, Louisiana has seen the devastating effects of Mother Nature's cold on our tropical crop. We also witnessed a year when the demand for our sugar was further reduced - as the soft drink industry elected to go to 100 percent corn sweeteners - and chemically produced artificial sweeteners grabbed increased shares of the sweetener market.

The price for sugar was less than most of us expected, as sugar prices stayed substantially below the Market Stabilization Price for much of the year. We wait in suspense as Congress debates the Farm Bill to see what type of program we can expect in the future - a program that everyone in the industry feels is vital to our existence.

The results of a year like 1984 and the prospects of 1985 place the Louisiana Sugar Industry in the predicament of worrying about its future. During the 20 years I have been in the business, similar negative overtones have existed, and in talking to others older than myself, pessimistic attitudes have been there for as long as they can remember. It's often said by people in the industry that if we get five or ten more years we will be lucky.

Many have felt that they cannot implement improvements or purchase certain equipment or buy land because the future of sugar in Louisiana is so uncertain. But we have been in this business for over 150 years as a vital, stable, and imperative industry to the economic and cultural history of South Louisiana. Let's look at the present conditions, but with optimism. Let's evaluate why we've been successful for 150 years despite predictions of doom and why we will be viable for another 150 years.

Sugar cane grows well in South Louisiana and despite our subtropical climate, it has held a comparative advantage over other crops tried in our area. The majority of production people are entirely dependent economically on sugar cane. With recent cut backs in the oil and petro-chemical industries in South Louisiana, any cut back in the sugar industry would bring economic chaos to the area.

Research and development have been the strong points of our industry. Plant breeders with the USDA and LSU have worked hard to develop new varieties. Agronomists have found ways to increase field and sugar yields by improving the cultural and fertilization practices employed by our farmers. Control methods for cane diseases, insects, weeds, and grasses have been developed and improved upon.

Our agricultural economists have stressed the need to evaluate and reduce costs to make our end product more competitive in the marketplace. The Cooperative Extension Service has always done an excellent job in getting these ideas to the field. In recent years the Audubon Sugar Institute has become a vital part of the processing picture. They have pursued more efficient and economical ways of extracting sugar from cane as well as new uses for sugar and its by-products.

The universities of the area have been strong in the education of local scientists and producers as well as scientists and producers from all over the sugar world. The American Sugar Cane League has been effective in the distribution of new varieties as well as in research and the coordination of research. If we are to go forward, these institutions and their programs have to continue and be improved upon. Vocal and financial support, both from the governmental and private sectors must continue for these important programs to be maintained.

The story of sugar through advertising has just started, but it must continue if we are to maintain and improve upon our share of the sweetener market.

Lastly there's the matter that is first and foremost on all of our minds that of legislative action. Leaders in our industry have long recognized the importance of some sort of price support program to maintain a stable industry and have been successful through our Sugar League and Washington representatives in conveying this message to our Congressional leaders.

Our lawmakers have, despite many long and exhaustive battles, seen fit to enact sugar legislation granting the industry its right to survive - maintaining for the consumers a stable and realistic price for sugar. The present program under the Farm Bill has been effective. It has not cost the government any money to subsidize producers, it has kept the cost to consumers at relatively low levels and, as a whole, it has been effectively administered, despite not achieving the MSP this past year.

We hope that our Congressional friends will be able to convey this message to Congress, resulting in the enactment of a program as close as possible to the present program.

The Louisiana Sugar Industry will survive and continue because the people in it want the industry to continue, South Louisiana needs the sugar industry economically, and the American consuming public needs the Domestic Sugar Industry.

PRESIDENT'S MESSAGE--FLORIDA DIVISION

Fritz C. Stein, Jr.
Belle Glade, FL

On behalf of the Florida Division of the American Society of Sugar Cane Technologists, I want to thank the Louisiana Division for hosting this 15th Annual Joint Conference in Fort Walton Beach, Florida.

I wear many hats. I am a member and serve on the Board of Directors of the Sugar Cane Growers Cooperative of Florida. Currently, I am a member of the State Agricultural Stabilization and Conservation Service Committee which supervises farm programs throughout Florida, and I serve as president of the Florida Sugar Cane League. The hat I wear best is that of a farmer. I am pleased to have the opportunity to present my comments as President of the Florida Division of the American Society of Sugar Cane Technologists.

We are very proud of the Florida sugar industry. Just a few months ago, we finished harvesting the largest crop of sugar cane in Florida's history - despite a hard freeze in January. During the 156 days of the 1984-85 harvesting season, Florida's 140 sugar cane growers harvested over 13 million tons of sugar cane, which the seven mills in Florida ground and manufactured into 1.41 million tons of raw sugar - making Florida the number one sugar producer in the United States.

We have been able to achieve this remarkable success to a large degree because of the efforts of many of you here today and ASSCT. We want to continue producing sugar in Florida and your help will be critical in the years ahead.

While this is a record crop for Florida, it certainly did not produce a record profit. All of the farmers and mill operators in Florida have had to economize and grind up to their capacity in order to lower unit costs. We believe we have made great strides in efficiency, but most of our farmers and mill operators are caught in a price squeeze between faster rising costs and income.

I am trained in sugar cane production and I work at it. I have to be as efficient as any other sugar cane farmer in order to stay in business. We are growing our crop on 368,000 acres of land especially suited for sugar cane. The mill and the production equipment used to grow and harvest sugar cane is extremely specialized and capital intensive. The total investment in mills and equipment in the Florida industry represents over $1 billion worth of farm capital.

Sugar is one of the world's most politicized and controlled commodities, making it very difficult for our sugar industry to compete under these conditions.

Most nations practice some sort of market intervention to protect their respective domestic sugar markets. According to a recent study, all major exporters guarantee producer price minimums, and most control exports and amounts available for domestic consumption.

The U.S. sugar industry, therefore, is not competing in a free market throughout the world, but against countries whose sugar industries are generally heavily subsidized or, as in the case of Cuba, operate under entirely different socio-economic and political objectives.

We have been fortunate. We have been able to maintain our ability to produce sugar in the United States in spite of heavy subsidization in other sugar-producing countries. Why? Mainly because we were able to include a sugar section in the 1981 Farm Bill which expires next year. This sugar section directed the U.S. Department of Agriculture to operate a non-recourse loan program for growers and first processors of sugar cane and sugar beets at a beginning level of 17 cents per pound and ending with the 1985-86 crop at 18 cents per pound. This program has kept domestic sugar prices, while well below cost of production in most areas, at a level where we can continue to operate.

Our industry is an efficient one, and is getting more efficient all the time. This is not an industry in which the inefficient are being maintained by an overly generous program. The current program has not guaranteed anyone a profit. That still has to be earned.

There are clouds on the horizon, however. The 1985 Farm Bill is now under consideration by the Congress. The Reagan Administration has come out squarely against increased costs in farm programs, and even though the sugar program costs the government nothing, they have proposed lowering the sugar loan program by 33 per cent to 12 cents per pound. In fact, the sugar program has made the U.S. Treasury $100 million through the collection of fees and tariffs on imported sugar under the quota system.

The Chamber of Commerce of the United States, the Sugar Users Group and the Consumer Federation of America have spoken in favor of lowering the loan rate for sugar. Their arguments are the same ones they have used in the past. We all know that they don't hold water, but that's no reason to lower our guard.

All segments of the domestic sweetener producers, including corn, are together in resolution that they favor continuation of a similar sugar program beginning at not lower than 18 cents per pound, with upward adjustments for inflation and production costs. All segments have representatives in Washington working to make sure this happens.

These representatives are working with members of Congress, their staff members, representatives of other commodities and others to ensure that they know the value of maintaining a domestic sugar industry. Not only are these representatives hard at work, but farmers like me are preparing to go to Washington when the time is right and do everything we can to save our business.

You might be asking why I am going on so much about the sugar program. Well, that is easy to answer. Simply stated - without the sugar program, there will be fewer of us at this meeting next year and maybe no meeting at all the following year.

Sugar is grown in only 17 states and in those 17 states only 38 of the total 435 Congressional Districts have sugar in them. That doesn't give sugar much clout in Congress. To get that clout, we must count on our friends from other agricultural commodities in strong coalition to succeed.

YOU CAN HELP! You all are involved in businesses. Your businesses buy things from suppliers not located in your state or Congressional District.

You have a responsibility to let these suppliers know how crucial passage of a domestic sugar bill is, not only to you but to them as well. Contact your suppliers directly and encourage them to contact their Senators and Congressmen.

The best farm bill would be a bill that would reduce spending, help balance the budget and reduce interest rates. That would add tremendously to farmers' ability to compete. About 20 per cent of farmers' production costs can be attributed to interest payments, so each percentage point reduction in the interest rate will put about $1 billion in farmers' pockets from decreased costs.

My sole concern is that we return profitability to agriculture and restore to this great endeavor of farming the dignity and self-respect it so richly deserves.

As a farmer, I like to produce but I cannot produce if I am losing money on what I grow. I believe that government has a role to play in agriculture. Presidents Lincoln and Jefferson both were given credit for saying, "Government is created to do for the people those things they cannot do for themselves." Two hundred years ago our forefathers all had to work to produce their food and fiber. Today, less than 3 per cent of our people produce food or fiber for the rest of us. In order to preserve this productivity, the government must have a role in agriculture the same as they have in defense, education, transportation, health and other areas.

FACTORS AFFECTING TOLERANCE OF SUGARCANE (SACCHARUM OFFICINARUM) TO HEXAZINONE

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ABSTRACT

In several Louisiana field experiments, sugarcane cultivar CP 65-357 was found to be highly sensitive to injury by hexazinone [3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H, 3H)-dione] when applied as the commercial product VELPAR at 1.1 to 2.2 kg ai/ha. Injury, as measured by reductions in yield of cane and sugar/ha, was more severe in plant cane than in ratoon cane and was much more severe on a silt loam soil that was low in both organic matter (1.3 to 1.6%) and clay content (17%) than on a soil that was higher in both organic matter (1.7%) and clay content (35%). A comparison of sugar yield for six cultivars on a typical silt loam soil with 1.6% organic matter and 17% clay showed that hexazinone at 1.1 kg/ha in plant cane caused a greater reduction in yield of CP 65-357 (42%) and CP 72-370 (40%) than of CP 70-321 (17%), CP 74-383 (18%), CP 73-351 (22%), and CP 72-356 (23%). The ratoon crop of all cultivars was much more tolerant to hexazinone at 1.1 kg/ha than was plant cane, but the treatment still reduced yields below the control. This study indicated that hexazinone can be used with minimal risk of injury to sugarcane if (1) the rate does not exceed about 1.0 kg/ha; (2) if treatment is made only on ratoon crops of moderately tolerant cultivars (avoiding use on such sensitive cultivars as CP 65-357 and CP 72-370); and (3) if treatment is confined to relatively fine textured soils having about 2% or greater organic matter and 30% or more clay content.

INTRODUCTION

Hexazinone has been found effective for preemergence and postemergence control of a wide range of broadleaf and gramineous weeds in sugarcane grown in the tropics and subtropics (2, 4, 5, 7). Phytotoxicity to sugarcane has been observed in many of these studies, but in Mauritius and South Africa, and apparently in many other neighboring countries as well, hexazinone at rates of 0.5 to 0.75 kg/ha, either alone or in mixtures, is considered relatively nonphytotoxic to ratoon cane (4, 7). Under Louisiana growing conditions, a rate of about 1.1 kg/ha generally is required for preemergence control of seedling johnsongrass [*Sorghum halepense* (L.) Pers.] on silt loam soils, but plant sugarcane has been injured by this treatment (5). Sugarcane infected with mosaic or ratoon stunting disease and treated with hexazinone has exhibited very large yield decreases (6).

This study was initiated to study the relationships of several factors - rate of application, soil type, crop stage, and cultivar sensitivity - that may influence injury by hexazinone under Louisiana growing conditions.

MATERIALS AND METHODS

A series of six field experiments were conducted from 1981 to 1984 near Chacahoula, Franklin, and Larose, Louisiana. The chemical and physical characteristics of the soil from a 15 cm depth in each experiment was determined by a commercial laboratory and is shown in Table 1.

Table 1. Average chemical and physical characteristics of soil in field experiments.

Experiment no. and location[1/]	Series	Texture	pH	Organic matter	Cation exchange capacity	Particle size analysis		
						Sand	Silt	Clay
				(%)	(meq/100g)	- - - -(%)- - - -		
Exp. 1 - Fr.	Baldwin	silt loam	5.6	1.3	13	18	65	17
Exp. 2 - Fr.	Baldwin	silty clay	4.8	2.0	31	14	41	45
Exp. 3 - Fr.	Baldwin	clay loam	6.3	2.1	20	28	43	29
Exp. 4 - Fr.	Baldwin	silt loam	5.6	1.3	13	18	65	17
Exp. 5 - Lr.	Commerce	silty clay loam	6.2	1.7	22	20	45	35
Exp. 6 - Ch.	Mhoon	silt loam	6.0	1.6	14	26	57	17

1/Ch. = Chacahoula, LA; Fr. = Franklin, LA; Lr. = Larose, LA.

Herbicide treatments in each of the experiments were applied in early April, following winter dormancy, when the autumn-planted or first-ratoon cane was about 35 to 45 cm tall. Hexazinone and other herbicides were applied in water sprays at 374 L/ha to a 91 cm band over rows spaced 1.7 m apart so that the line of sugarcane was in the center of the treated band.

Herbicides were applied as nondirected soil treatments, and most of the sugarcane leaves were wet by the spray. Rates of herbicides are expressed as the amount of active ingredient (ai) or acid equivalent (ae) broadcast to a hectare of land. All plots, including the nontreated control, were maintained weed-free by hoeing so that the effect of herbicide treatments on sugarcane yield could be measured without interference from weed competition. Standard-practice controls, included in Experiments 1 through 5, were either a mixture of terbacil [5-chloro-3-(1,1-dimethylethyl)-6-methyl-2,4(1H,3H)-pyrimidinedione] at 1.6 kg ai/ha and fenac (2,3,6-trichlorobenzeneacetic acid) at 1.7 or 2.0 kg ae/ha, or a mixture of pendimethalin [N-(1-ethyl-propyl)-3,4-dimethyl-2,6-dinitrobenzenamine] at 3.3 kg ai/ha and fenac at 3.0 kg ae/ha. Hexazinone, terbacil, fenac, and pendimethalin were applied as the commercial formulations VELPAR, SINBAR, FENATROL, AND PROWL, respectively[1/].

Experiments 1, 2 and 3 were conducted in 1981 on plant cane of CP 65-357, plant cane of CP 70-321 and first-ratoon cane of CP 65-357, respectively, each on a different soil type. Hexazinone was applied at 1.1, 1.7 and 2.2 kg ai/ha in each experiment.

Experiments 4 and 5 were essentially identical except for differences in soil type. Hexazinone at 1.2 and 1.6 kg/ha were applied to plant cane of CP 65-357 in 1981 and to the first ratoon in 1982. The experiments were designed so that half the plots in a replicate were treated in plant cane and half in the first ratoon. The percent reduction in yield caused by herbicide treatments, as compared to the nontreated control, was determined for each crop and served as a basis for determining relative tolerance of each crop to hexazinone.

In Experiment 6, hexazinone at 1.1 kg/ha was applied to cultivars CP 65-357, CP 70-321, CP 72-356, CP 72-370, CP 73-351, and CP 74-383 in plant cane and in the first ratoon. The percent reduction in yield for plant cane and for the first ratoon was compared as described for Experiments 4 and 5.

In Experiments 1 through 5, plots 3 rows (5.1 m) wide by 13.7 m long were arranged in a randomized complete block design with 6 replicates. Experiment 6 was a split-plot design with herbicide treatments the whole plots and cultivars the subplots (5.1 m wide by 6.4 m long) with 5 replicates (plant crop) or 8 replicates (first-ratoon crop).

Plots in each experiment were harvested in November or December with a whole stalk mechanical harvester that was set to top the tallest plants in the first hard internode below the apical meristem. A 15-stalk sample from each plot was crushed once in a three-roller sample mill; the juice analyzed for brix by hydrometer and for apparent sucrose by polarimetry (3); and sugar content (sugar/ton of cane) calculated (1). The yield of cane/ha and/or sugar/ha was used as a quantitative measure of sugarcane injury.

RESULTS AND DISCUSSION

The effect of three rates of hexazinone - 1.1, 1.7 and 2.2 kg/ha - on sugar yield, as compared to hand-weeded and standard-practice controls, varied by experiment (Table 2). Yield of cultivar CP 65-357 plant cane on silt loam in Experiment 1 was reduced by 39, 75 and 89%, respectively; yield of CP 65-357 first-ratoon on clay loam in Experiment 3 was reduced by 11, 29 and 56%, respectively; and yield of cultivar CP 70-321 plant cane on silty clay in Experiment 2 was reduced by only 2, 10 and 13% respectively. The large reduction in sugar yield of CP 65-357 was the result of reduction in both yield of cane/ha and sugar content of cane, but the reduction in sugar yield of CP 70-321 was primarily caused by a reduction in yield of cane/ha (data not presented).

[1/] Trade names are used solely for the purpose of providing specific information, and such mention is not intended to imply endorsement of their use by the U. S. Department of Agriculture.

Table 2. Effect of rate of hexazinone on yield of sugarcane.

Herbicide & rate (kg/ha)	Yield of sugar & reduction (%) from hand-weeded control[1] Plant cane CP 65-357 on silt loam (Exp. 1-1981)	Plant cane CP 70-321 on silty clay (Exp. 2-1981)	First-ratoon CP 65-357 on clay loam (Exp. 3-1981)
	(kg/ha)		
Hexazinone-1.1	6700 (39%) c	10900 (2%) b	7500 (11%) c
Hexazinone-1.7	2800 (75%) b	10000 (10%) a	6000 (29%) b
Hexazinone-2.2	1200 (89%) a	9700 (13%) a	3700 (56%) a
(Terbacil-1.7 + Fenac-1.7)[2]	11000 (0%) d	10900 (2%) b	8500 (0%) d
None (hand-weeded)	11000 (0%) d	11100 (0%) b	8400 (0%) d

[1]Means within an experiment followed by the same letter are not significantly different at the 0.05 level of probability as determined by the Duncan's multiple range test.

[2]Standard-practice control.

These experiments showed that the phytotoxicity of hexazinone was closely related to rate of application, with the greatest percentage decrease in yield occurring as the rate increased from 1.1 to 1.7 kg/ha (Table 2). Phototoxicity at a given rate also was influenced by other factors such as soil type, crop stage and cultivar. These variables were studied in more detail in subsequent experiments.

A comparison of sugar yield for CP 65-357 plant cane on different soils in Experiments 4 and 5 (Table 3) shows that hexazinone at 1.2 and 1.6 kg/ha reduced yields by 51 and 73%, respectively, on the silt loam in Experiment 4, but reduced yield only by 9 and 13%, respectively, on the silty clay loam in Experiment 5. Apparently, the higher clay and organic matter content and cation exchange capacity of the soil in Experiment 5 as compared to that in Experiment 4 (Table 1) was important in preventing large yield reductions from hexazinone. Similar results were obtained in another study (5).

Table 3. Comparative effect of hexazinone on the plant and first-ratoon crops of CP 65-357.

Herbicide & rate (kg/ha)	Yield of sugar & reduction (%) from hand-weeded control[1] Plant cane 1981	First-ratoon 1982
	(kg/ha)	
	Experiment-4 on silt loam	
Hexazinone-1.2	6000 (51%) b	9200 (15%) b
Hexazinone-1.6	3300 (73%) a	7100 (34%) a
(Terbacil-1.6 + Fenac-2.0)[2]	12000 (2%) c	10300 (5%) c
None (hand-weeded)	12200 (0%) c	10800 (0%) c
	Experiment-5 on silty clay loam	
Hexazinone-1.2	10900 (9%) a	10400 (11%) a
Hexazinone-1.6	10400 (13%) a	9800 (16%) a
(Pendimethalin-3.3 + Fenac-3.0)[2]	11600 (3%) b	11600 (1%) b
None (hand-weeded)	12000 (0%) b	11700 (0%) b

[1]Means followed by the same letter within the same crop of an experiment are not significantly different at the 0.05 level of probability as determined by the Duncan's multiple range test.

[2]Standard-practice or anticipated standard-practice control.

Hexazinone is characterized as being moderately adsorbed by soil colloids and is relatively mobile in soils (8). Sugarcane injury probably was caused by the leaching of the herbicide into the root zone. The leaching of many herbicides decreases as the soil adsorptive capacity increases. The clay and organic matter content of soil greatly affect their absorptive capacity.

In Experiment 4, hexazinone treatments were more than twice as phytotoxic when applied to plant cane as when applied to the first ratoon of the same planting (Table 3). Even though ratoon cane was more tolerant to hexazinone, the lowest rate of 1.2 kg/ha still reduced yield of CP 65-357 by 15%. Similar reductions in ratoon yields were found in Experiment 3 (Table 2) and Experiment 5 (Table 3).

The yield response of six cultivars treated with hexazinone at 1.1 kg/ha in plant cane and in the first-ratoon in Experiment 6 is shown in Tables 4 and 5, respectively. The silt loam soil was typically low in organic matter (1.6%) and contained 17% clay. Hexazinone had caused injury to sugarcane on this type of soil in previous experiments (5, 6).

A statistical analyses of plant cane yield data for Experiment 6 showed a significant interaction between cultivars and hexazinone treatment for several yield parameters - millable stalks/ha, cane/ha and sugar/ha (Table 4). The interactions were primarily caused by the greater reduction in yield of CP 65-357 and CP 72-370 as compared to the other cultivars.

Table 4. Yield of plant sugarcane following a spring application of hexazinone at 1.1 kg/ha on silt loam (Exp. 6-1983).

Herbicide treatment	Cultivar CP 65-357	CP 70-321	CP 72-370	CP 72-356	CP 73-351	CP 74-383	Mean[2/]
			Number millable stalks/ha				
None	56200	60900	60500	59700	70000	57600	60800
Hexazinone	34700	51500	43000	48500	61500	50100	48200
(% reduction)	(38)	(15)	(29)	(19)	(12)	(13)	(21)
(LSD - 5700)[1/]							
			Tons cane/ha				
None	75	73	70	73	70	71	72
Hexazinone	45	62	46	59	60	61	56
(% reduction)	(40)	(16)	(34)	(19)	(14)	(13)	(23)
(LSD - 6)[1/]							
			Kg sugar/ton of cane				
None	126	129	136	129	127	118	127 b
Hexazinone	121	128	123	122	116	111	120 a
(% reduction)	(4)	(1)	(9)	(5)	(9)	(6)	(6)
Mean[2/]	123 b	129 c	130 c	125 bc	121 b	115 a	
			Kg sugar/ha				
None	9400	9500	9500	9300	8900	8300	9200
Hexazinone	5500	7900	5700	7200	7000	6800	6700
(% reduction)	(42)	(17)	(40)	(23)	(22)	(18)	(27)
(LSD - 900)[1/]							

[1/]LSD = Least significant difference at 0.05 level of probability as determined by a t-test for two herbicide-treatment means at a given cultivar or for two cultivar-treatment means at a given herbicide treatment.

[2/]Overall means followed by the same letter are not significantly different at the 0.05 level of probability as determined by the Duncan's multiple range test.

Hexazinone primarily injured plant sugarcane by reducing the capacity of cultivars to produce millable stalks (Table 4). Since number of millable stalks/ha is a key component of yield, any reduction causes a corresponding loss in yield of cane and sugar/ha. Reductions in yield of cane/ha were greater for CP 65-357

(40%) and CP 72-370 (34%) than for CP 72-356 (19%), CP 70-321 (16%), CP 73-351 (14%) and CP 74-383 (13%). Hexazinone reduced sugar content of stalks (sugar/ton of cane) by 6% as an average for all cultivars.

No significant interaction was found between cultivar and hexazinone treatment in the first-ratoon crop (Table 5), and the yield response of each cultivar is considered the same. However, hexazinone caused numerically larger yield reductions in CP 65-357 and CP 72-370 than in other cultivars. The experiment may not have had sufficient precision to detect such differences because of a winter freeze in 1983 (-10.6 C) that adversely affected stands of several cultivars, particularly CP 65-357, CP 70-321, and CP 72-370. Hexazinone reduced ratoon yields of cane and sugar/ha by 5 and 6%, respectively, below the nontreated control which was considerably less than the 23 and 27% reduction, respectively, found for plant cane. Sugar content of stalks was not reduced by the treatment. These results show that cultivars as a group are more tolerant to hexazinone in the ratoon crop than in the plant-cane crop and support the results of Experiment 4 (Table 3) and the studies in Mauritius and South Africa (2, 7).

Table 5. Yield of first-ratoon sugarcane following a spring application of hexazinone at 1.1 kg/ha on silt loam (Exp. 6-1984).

Herbicide Treatment	CP 65-357	CP 70-321	CP 72-370	CP 72-356	CP 73-351	CP 74-383	Mean[1]
	Cultivar						
			Number millable stalks/ha				
None	43600	58800	64400	71100	67300	62400	61300 a
Hexazinone	42100	60200	56800	69600	65200	62400	59400 a
(% reduction)	(3)	(0)	(12)	(2)	(3)	(0)	(3)
Mean[1]	42900 a	59500 b	60600 b	70400 d	66300 c	62400 bc	
			Tons cane/ha				
None	48	56	60	68	54	63	58 b
Hexazinone	44	55	53	65	53	61	55 a
(% reduction)	(8)	(2)	(12)	(3)	(2)	(3)	(5)
Mean[1]	46 a	56 b	57 b	66 d	54 b	62 c	
			Kg sugar/ton of cane				
None	120	136	137	134	122	120	128 a
Hexazinone	117	134	137	132	119	121	127 a
(% reduction)	(3)	(1)	(0)	(2)	(2)	(0)	(1)
Mean[1]	119 a	135 bc	137 c	133 b	121 a	120 a	
			Kg sugar/ha				
None	5800	7600	8300	9100	6600	7600	7500 b
Hexazinone	5200	7400	7300	8600	6300	7400	7000 a
(% reduction)	(11)	(3)	(12)	(5)	(5)	(3)	(6)
Mean[1]	5500 a	7500 c	7800 c	8800 d	6500 b	7500 c	

[1]Means followed by the same letter are not significantly different at the 0.05 level of probability as determined by the Duncan's multiple range test.

This study shows that hexazinone even at a relatively low rate of about 1.1 kg/ha, applied in a band to only half of the sugarcane row, can cause severe yield reduction in sugarcane. The data indicate, however, that losses in cane and sugar yield can be minimized or eliminated by (1) confining treatments to relatively fine textured soils having about 2% or more organic matter and 30% or more clay; (2) confining treatment to ratoon crops; and (3) avoiding use on very sensitive cultivars such as CP 65-357, CP 72-370, CP 48-103 and NCo 310 as determined in this and other studies (5, 6).

These same precautions probably are necessary even when using rates of hexazinone lower than 1.1 kg/ha, such as in herbicide mixtures, since significant yield reductions have been observed on first-ratoon CP 65-357 on silt loam at rates as low as 0.3 kg/ha (data not presented).

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COMPOSITION OF SUGARCANE JUICE AS AFFECTED BY POST-FREEZE DETERIORATION OF STALKS

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ABSTRACT

Eight commercial or candidate sugarcane varieties, CP 70-321, CP 72-356, CP 72-370, CP 74-383, CP 76-301, CP 76-331, L 65-69, and NCo 310, planted in a replicated field test at Houma, Louisiana, were exposed to a freeze (minimum temperature, -10.6°C) on December 25, 1983. Stalks of all varieties were frozen to the ground. Juice deterioration at 10, 12, and 15 days after the freeze was measured by changes in the concentration of apparent sucrose, pH, titratable acidity and dextran content. Pre-freeze differences among varieties were significant for apparent sucrose and titratable acidity, but not for pH and dextran content; whereas, post-freeze differences were significant for all parameters. The data showed the expected decrease in apparent sucrose and pH and increases in titratable acidity and dextran content with time after the freeze. A more detailed study of three varieties, CP 70-321, CP 72-370, and L 65-69, showed post-freeze differences in sucrose, glucose, fructose, and total polysaccharide (gum). With regard to sucrose, the relative rankings for varieties, as well as actual concentration, were similar whether determined by polarization or by high-performance liquid chromatography (HPLC), independent of dextran concentrations. Also, the relative ranking of varieties according to their dextran levels remained the same whether the haze or the Roberts' copper method was used, but the concentrations of dextran determined by the two methods differed significantly from each other.

INTRODUCTION

In general, sugarcane (Saccharum spp.) damaged by a severe freeze produces juice of lowered purity and sucrose, increased titratable acidity and an abnormally high amount of dextran and gum (polysaccharide) (3, 7, 8, 13, 14, 19). As early as 1938, Fort and Lauritzen (5, 6) reported that an increased gum content accompanied the formation of excess acidity in the juice of frozen sugarcane. Later, Lauritzen et al. (17) related changes in juice composition to the degree of freeze injury. The greater the extent of injury (number of buds killed), the more rapid the increase in gum and acidity with a simultaneous decrease in Brix, sucrose and purity.

Following freeze injury, dead and moribund cells become vulnerable to invasion by the bacterium, Leuconostoc mesenteroides. This bacterium, which is ubiquitous in cane fields, utilizes sucrose and produces dextran as a by-product (15). The bacterium's entry into storage tissue is facilitated by dead lateral buds, occurring with temperatures below -4.4°C or 24°F and by freeze cracks, occurring with temperatures below -5.6°C or 22°F. An increase in the level of dextran is not the only symptom of Leuconostoc involvement in post-freeze deterioration. As the organism consumes sucrose, there is a release of fructose along with a lowered pH of the juice (11). Irvine and Legendre (15) proposed two mechanisms for deterioration: 1) susceptibility of tissue to freezing; and, 2) susceptibility to the formation of dextran and/or polysaccharide after the freeze. In those studies, CP 70-321 had been identified as among the most resistant variety to deterioration following freezing, whereas L 65-69 was among the least. CP 72-370 was found to be intermediate in deterioration following freezing.

December 25, 1983, brought a record daily low temperature for December, -10.6°C (13°F) at Houma, Louisiana, as farmers were harvesting the last of their crop. Following the freeze, the weather remained cool throughout the 15-day sampling period with an average temperature of 4.9°C (41°F). When the sugarcane stalks and soil began to thaw on the afternoon of December 26, it became apparent that all stalk tissue in all varieties was frozen to ground level. Tops began to fall several days later and, during the second week after the freeze, the stalks of some varieties bent near ground level producing a lodging effect not usually seen in cane. The post-freeze period was the first opportunity for field evaluation of the deterioration of several sugarcane varieties grown predominantly in Louisiana.

The objectives of this study were to determine the changes in juice composition of sugarcane as affected by post-freeze deterioration, to compare methods of analyses, and to determine the associations among juice components as they relate to deterioration.

MATERIALS AND METHODS

Variety trials for estimating cold tolerance in the field are planted annually at Houma, Louisiana. From 8 to 15 varieties are planted in the fall of each year, and they are sampled repeatedly during the winters of the following years. Planting is done on raised ridges 1.8 meters apart; variety plots are 12 m long and 3 rows wide. The experimental design is a randomized block with 4 replications. After planting, the cane is covered with 5 cm of firm soil and, when spring regrowth appears, soil is drawn to the new shoots with repeated cultivations. Weeds are controlled with a standard pre-emergence herbicide, and the cane is fertilized with ammonia at approximately 90 kg N/ha.

The eight varieties planted in the fall of 1982 for estimation of cold tolerance include: CP 70-321, CP 72-356, CP 72-370, CP 74-383, CP 76-301, CP 76-331, L 65-69 and NCo 310. All are, or have been grown, commercially in Louisiana with the exception of CP 76-301. CP 76-301 was a candidate variety for commercial release; however, it was dropped from the testing program in 1984 because of low yields in the stubble crop.

Sampling commenced on December 23 and continued until January 9, 1984. Sampling was confined to the center row of the three-row plot, and 15-stalk samples were taken serially along the row on each sampling date. Stalks were cut at ground level by hand and topped approximately at the position of the terminal bud.

Stalks were crushed once in a 3-roll sample mill, and the expressed juice subsampled after thorough mixing. Laboratory analyses of one set of subsamples were performed by standard methods: Brix by hydrometry; apparent sucrose (as % of juice) by polarimetry following clarification with lead subacetate; dextran by the haze or CSR method (10, 16, 18, 20); juice pH with a pH meter; and, juice acidity by titration. The latter was done by quantifying the volume of 0.1N NaOH required to raise the pH of 50 ml of juice to pH 8.3; data are expressed in terms of volume of 0.1N NaOH/10 ml of juice.

Samples of juice from badly deteriorated cane, which did not clarify with lead subacetate, were clarified by the Herles method (1). With this method, juice (52 g) is placed in a sugar flask and 5 ml of an aqueous solution of neutral lead nitrate (500 g/L) is added, followed by 5 ml of an aqueous solution of sodium hydroxide (50 g/L). The sample and reagents are mixed and allowed to settle. If clarification is satisfactory, the sample is diluted to volume, mixed and filtered. If not clarified, a new sample is weighed, and up to 15 ml of each reagent may be added for each sample. Pol is measured in tubes of appropriate length, and corrections are made for length and dilution.

A second set of subsamples were frozen immediately after milling and transported to Sugar Processing Research, Inc. (SPRI), New Orleans, for a more detailed analysis of three of the eight varieties included in the study: CP 70-321, CP 72-370 and L 65-69. Sucrose, glucose and fructose were analyzed by high-performance liquid chromatography (HPLC) using a Biorad HPX-87C carbohydrate column (2); dextran by Roberts' copper method (21); and, total polysaccharides as the alcohol-insoluble reactants with phenol-sulfuric acid (22).

The data for each parameter were subjected to analyses of variance and the means separated by Least Significant Difference (LSD) Tests (23). The data were also analyzed by linear regression and correlation coefficients among variables were computed.

RESULTS AND DISCUSSION

Examination of the large amount of data accumulated over a ten year period showed that deterioration of sugarcane following freezing is best measured by juice sucrose, titratable acidity and dextran content (Tables 1-3). Cane sampled just before the freeze produced juice of excellent quality with expected significant varietal differences in sucrose and titratable acidity, but not in dextran content. Samples taken at 10 and 12 days after the freeze showed extensive changes in juice composition and, by the 15th day, all varieties were unacceptable for commercial processing. At that time significant varietal differences in sucrose, titratable acidity and dextran content were obtained, just as there were at 10 and 12 days after the freeze. The variety CP 70-321 was superior on all post-freeze sampling dates, having the highest sucrose content and lowers titratable acidity and dextran content. The variety NCo 310 exhibited good keeping qualities on the 10th day but subsequently deteriorated.

Table 1. Post-freeze changes in apparent sucrose content of eight varieties at Houma, Louisiana.

Variety	Apparent sucrose (%) [1/] Days after freeze [2/] -2	10	12	15
CP 70-321	17.53	15.87	16.26	13.12
CP 72-356	16.51	15.12	13.89	9.06
CP 72-370	17.45	15.47	15.70	11.88
CP 74-383	17.48	15.74	14.90	11.07
CP 76-301	16.16	14.92	11.72	9.85
CP 76-331	18.71	17.10	14.99	10.50
L 65-69	17.01	14.52	10.48	6.34
NCo 310	15.70	15.00	13.58	5.71
LSD .05	1.01	0.87	2.51	4.70

1/Apparent sucrose by polarization.

2/Freeze, -10.6°C on December 25, 1983.

Table 2. Post-freeze changes in titratable acidity of eight varieties at Houma, Louisiana.

Variety	Titratable acidity (ml 0.1N NaOH/10 ml juice) Days after freeze [1/] -2	10	12	15
CP 70-321	1.96	2.14	3.20	6.68
CP 72-356	2.54	3.20	5.11	9.70
CP 72-370	2.14	2.82	3.83	7.84
CP 74-383	2.07	2.61	3.95	7.12
CP 76-301	2.11	2.98	4.61	7.24
CP 76-331	2.32	2.73	4.73	8.32
L 65-69	2.38	3.21	5.56	7.79
NCo 310	2.30	2.57	4.57	7.84
LSD .05	0.24	0.32	0.68	1.56

1/Freeze, -10.6°C on December 25, 1983.

Table 3. Post-freeze changes in dextran content of eight varieties at Houma, Louisiana.

Variety	Dextran control [1/] (mg/ml) Days after freeze [2/] -2	10	12	15
CP 70-321	0.10	0.51	4.28	8.09
CP 72-356	0.12	1.38	10.10	15.15
CP 72-370	0.11	0.86	5.92	10.58
CP 74-383	0.11	0.79	7.08	11.35
CP 76-301	0.11	1.27	10.66	11.85
CP 76-331	0.11	0.73	6.91	12.68
L 65-69	0.10	1.38	10.15	14.92
NCo 310	0.10	0.73	7.28	14.60
LSD .05	NS	0.49	2.60	4.57

1/Dextran by haze method.

2/Freeze, -10.6°C on December 25, 1983.

A second analysis for dextran using Roberts' copper method for three varieties, CP 70-321, CP 72-370 and L 65-69, showed a considerably lower concentration than that found using the haze method (Table 4). CP 70-321 had the lowest concentration of dextran throughout the sampling period and L 65-69 had one of the highest (Table 3). However, when the concentration of dextran for L 65-69 was measured by the Roberts' copper method, it was lower than that found for CP 70-321 or CP 72-370 at 15 days after the freeze. On the initial sampling date using unfrozen cane, the two methods gave similar results; however, with time following the freeze the haze methods gave dextran concentrations from 3 - 20 times that found by the Roberts' copper method. The reason for this difference is that the haze method is not specific for dextran and the results indicated that other polysaccharides interfered with the method, inflating results (21). The Roberts' copper method for dextran separates all polysaccharides from the sugar and the dextran is selectively precipitated with alkaline copper sulfate.

Table 4. A comparison of analytical methods for the determination of dextran content of three varieties as affected by post-freeze deterioration at Houma, Louisiana.

Variety	Method of Analysis1/	Dextran content (ppm, dry weight x 1000)			
		Days after freeze2/			
		-2	10	12	15
CP 70-321	Haze	0.534	3.017	24.660	58.755
	Roberts'	0.206	0.941	6.837	18.958
CP 72-370	Haze	0.591	5.228	35.500	84.994
	Roberts'	0.771	8.077	15.210	24.226
L 65-69	Haze	0.551	9.004	92.932	231.497
	Roberts'	0.246	14.243	10.547	10.751
LSD .05	Haze	NS	2.396	12.569	22.860
	Roberts'	NS	6.148	6.887	10.045

1/Haze method, samples analyzed at Houma, Louisiana; Roberts' copper method, samples analyzed at Sugar Processing Research, Inc., New Orleans, Louisiana.

2/Freeze, -10.6°C on December 25, 1983.

An effect of dextran in sugarcane juice is its interference with analytical tests for sucrose and purity (11). Dextran is highly dextrorotatory and therefore can inflate the direct polarization reading of juice samples, unless removed prior to analysis. High-performance liquid chromatography (HPLC) separates and quantifies sucrose while polarization detects a combination of optically active substances. A comparison of the two analytical methods for the determination of sucrose content is shown in Table 5. Although it was shown in Table 4 that the juice had an appreciable amount of dextran, especially with time after the freeze, there were no significant differences in sucrose content between the two analytical procedures. A correlation analysis between apparent sucrose as measured by polarization and sucrose by HPLC for the samples of three varieties, CP 70-321, CP 72-370 and L 65-69, gave a highly significant r value of 0.97. Apparently, dextran as well as other polysaccharides, were removed from the juice by the clarifying agent, lead subacetate, when sucrose was measured by polarization.

Concurrent with the increase in dextran concentration that occurs in deteriorating sugarcane juice is an increase in the amount of fructose. According to Imrie and Tilbury (11) Leuconostoc mesenteroides is a sucrose-metabolizing organism. Sucrose is converted to dextran by the enzyme dextran-sucrase leaving fructose as a by-product. Dextran consists of a basic straight-chain polymer of α-(1 -> 6) linked glucose units, with some branches linked by α-(1 -> 3) or α-(1 -> 4) glucoside bonds, leaving most of the fructose behind in solution. As expected, the composition of sugarcane juice as affected by post-freeze deterioration showed a significant increase in fructose on each date of analysis and for each of the three varieties (Table 6). On the other hand, the glucose content increased only slightly between the pre-freeze sampling date and 10 days after the freeze for two

of the three varieties; thereafter, no change in glucose content occurred. No change was noted for the variety L 65-69 throughout the sampling period. Total simple sugar (glucose and fructose) was lowest on the pre-freeze harvest date while sucrose was highest; after which, as the concentration of simple sugar (predominately fructose) increased, the concentration of sucrose decreased.

Table 5. A comparison of analytical techniques for the determination of sucrose content of three varieties as affected by post-freeze deterioration at Houma, Louisiana.

Variety	Method of Analysis [1]	Sucrose content (%) Days after freeze[2] -2	10	12	15
CP 70-321	AS	17.53	15.87	16.26	13.12
	HPLC	18.26	16.87	15.15	12.57
CP 72-370	AS	17.45	15.47	15.70	11.88
	HPLC	17.89	16.18	14.74	11.94
L 65-69	AS	17.01	14.52	10.48	6.34
	HPLC	16.31	14.21	9.66	7.02

[1] AS as apparent sucrose by polarization analyzed at Houma, Louisiana; HPLC as high-performance liquid chromatography analyzed at Sugar Processing Research Inc., New Orleans, Louisiana.

[2] Freeze, -10.6°C on December 25, 1983.

Table 6. Post-freeze changes in invert sugar (glucose and fructose) of three varieties as affected by post-freeze deterioration at Houma, Louisiana.

Variety	Invert Sugar (%) [1] Days after freeze[2] -2		10		12		15		LSD	.05
	GLU	FRU	GLU	FRU	GLU	FRU	GLU	FRU	GLU	FRU
CP 70-321	0.18	0.19	0.46	0.59	0.51	1.33	0.52	1.74	0.11	0.35
CP 72-370	0.03	0.17	0.35	0.74	0.42	1.68	0.46	2.18	0.12	0.54
L 65-69	0.27	0.31	0.33	1.42	0.25	2.90	0.28	3.43	NS	1.30
LSD .05	0.06	0.02	NS	0.63	0.14	0.80	0.07	1.27	----	----

[1] GLU = Glucose; FRU = Fructose. Analyzed by HPLC at Sugar Processing Research, Inc., New Orleans, Louisiana.

[2] Freeze, -10.6°C on December 25, 1983.

An increase in soluble polysaccharide (gum) of sugarcane juice has been associated with lower quality (5). Although U. S. Mainland sugarcane producers have long used titratable acidity as a quality indicator, Irvine (13) noted that the levels of titratable acidity may be influenced by location or other factors, and normal cane may have titratable acidity at levels exceeding the lower permissible penalty level (12). In the present study there was no statistical difference in total polysaccharide on the pre-freeze sampling date, although, L 65-69 had nearly twice the measurable gum of CP 70-321 (Table 7). At day 10 and 12, L 65-69 had significantly higher gum than both CP 70-321 and CP 72-370. By day 15, it appeared that gum levels were biased by the presence of protein (yeast, bacteria) which interfered with the measurement. It is interesting to note that while L 65-69 showed the highest initial dextran formation after the freeze, it did not continue to produce dextran but did produce additional gum. On the other hand, the variety CP 72-370, while initially producing less dextran than L 65-69 on day 10 after the freeze, produced more than either CP 70-321 or L 65-69 by day 12 and again on day 15. The variety CP 70-321 is clearly most resistant to deterioration. These data support the previous findings of Irvine and Legendre (15).

Table 7. Post-freeze changes in total polysaccharides of three varieties as affected by post-freeze deterioration at Houma, Louisiana.

Variety	Total polysaccharides (ppm, dry weight x 1000)			
	Days after freeze1/			
	-2	10	12	15
CP 70-321	1.059	4.357	10.105	--
CP 72-370	1.420	10.768	23.663	--
L 65-69	1.813	18.978	62.656	--
LSD .05	NS	4.746	34.322	--

1/Freeze, -10.6°C on December 25, 1983.

Dextran content (PPM in juice) was regressed on the other quality indicators; regression coefficients, correlation coefficients and coefficients of determination are shown in Table 8. All regression and correlation coefficients were significantly different from zero at the 1% level of probability. The coefficients of determination (r^2) indicate that two of the independent variables, pH and titratable acidity, are closely associated with an increase in dextran content and, therefore could be used to predict that deterioration had occurred. On the other hand, apparent sucrose was not (r^2 = 0.27) and should not be used as an indicator of deterioration. These findings are in keeping with the results of Gascho et al. (9) who reported a highly significant correlation between juice pH and dextran (r = -0.90**) when studying sugarcane deterioration during storage. However, they found that dextran measurements appeared slightly more sensitive.

Table 8. Regression coefficients, correlation coefficients (r) and coefficients of determination (r^2) for several parameters of post-freeze deterioration of three sugarcane varieties. 1/

y†	X	a	b	r	r^2
Dextran (ppm, juice)	Apparent sucrose(%)	5356.86	-251.70**2/	-0.52**	0.27
Dextran (ppm, juice)	pH	13426.25	-2318.65**	-0.80**	0.64
Dextran (ppm, juice)	Titratable acidity (ml 0.1N NaOH/10 ml juice)	-452.21	571.30**	0.79**	0.62
pH	Apparent sucrose(%)	3.02	0.141**	0.84**	0.71
pH	Titratable acidity (ml 0.1N NaOH/10 ml juice)	5.98	-0.244**	-0.98**	0.95
Titratable acidity (ml 0.1N NaOH/10 ml juice)	Apparent sucrose (%)	12.19	-0.585**	-0.87**	0.76

1/Freeze, -10.6°C on December 25, 1983; Varieties, CP 70-321, CP 72-370 and L 65-69.

2/Significant at the 0.01 probability level.

† y = a + bX.

Correlation analyses for pH and apparent sucrose, pH and titratable acidity, and titratable acidity and apparent sucrose showed a close interrelationship among these three indicators of deterioration (Table 8). The coefficients of determination (r^2) of 0.71, 0.95 and 0.76, respectively, indicated that any one of the three variables was a reasonably good predictor of the other. However, according to Fort and Lauritzen (4), the use of excess acidity (titratable acidity) rather than total acidity (pH) is recommended for the evaluation of deteriorated cane.

SUMMARY

The results of this study suggest that when all variety differences due to the resistance of tissue to freezing are removed (as was the case in this study) there are still highly significant differences in the rate of deterioration and these differences can be very important in sugar processing. Since tissue resistance was not a factor in this study, and since varietal differences were still evident, it is possible that resistance to deterioration is related to resistance to the dextran-producing microorganism, Leuconostoc mesenteroides.

Deterioration was initially measured by changes in Brix, apparent sucrose, apparent purity, pH, titratable acidity and dextran content of the juice. Significant pre-freeze differences occurred among varieties for Brix, apparent sucrose and purity and titratable acidity, but not for pH and dextran content. Post-freeze varietal differences were sometimes evident for all parameters. A more detailed analysis of juice for three varieties showed that apparent sucrose by polarization and true sucrose by high-performance liquid chromatography (HPLC) gave similar results even when the dextran of the juice was excessive. Although there was an apparent relationship in the dextran content of the juice as measured by the haze and Roberts' copper methods, the haze method was non-specific for dextran, giving values from 3 - 20 times higher than the Roberts' copper method in severely deteriorated juice. Results also showed that fructose can be used as a measure of deterioration. While glucose remained essentially constant throughout the sampling period, the level of fructose increased as sucrose was consumed by the apparent action of the Leuconostoc microorganism.

These data suggest a close relationship between post-freeze deterioration of sugarcane varieties and the apparent sucrose, pH, titratable acidity and dextran content of their juices. Juice sucrose and dextran content are important factors in recovery of sugar by the factory, and should be given consideration in selecting varieties for resistance to deterioration following a freeze.

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SEASONAL ACTIVITY OF PARASITOIDS AGAINST SUGARCANE BORER LARVAE IN FLORIDA

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ABSTRACT

The seasonal activity of parasitoids against larvae of the sugarcane borer, *Diatraea saccharalis* (F.), in Florida was investigated during 1982, 1983, and 1984. The total percentage of borers parasitized each season ranged from 5 to 20% during the spring and early summer and steadily increased thereafter through late fall. Late season parasitism levels reached 58, 42, and 61% by mid-October during 1982, 1983, and 1984, respectively. *Agathis stigmatera* (Cresson) and *Cotesia flavipes* (Cam.) were the only important parasitoids of sugarcane borer larvae, but extremely low population levels of other hymenopterous parasitoids were present. Low to moderate parasitism levels (e.g., 5 to 20%) by *A. stigmatera* persisted throughout each season. In contrast, *C. flavipes* was relatively inactive against sugarcane borers early during each growing season, but during July, population levels of this parasitoid began to increase. By the end of October, 40 to 55% of all borers dissected were parasitized by *C. flavipes*. The study showed *A. stigmatera* and *C. flavipes* are important mortality factors of sugarcane borers in Florida.

INTRODUCTION

Agathis stigmatera (Cresson) and *Cotesia* (= *Apanteles*) *flavipes* (Cam.) are braconid parasitoids of the sugarcane borer, *Diatraea saccharalis* (F.), in Florida. Both parasitoids are endoparasitic and attack sugarcane borer larvae. Eggs of these parasitoids are oviposited directly into borer larvae. *A. stigmatera* is a large, solitary parasitoid that was introduced into Florida from Peru during 1932 (3); within 9 years, this parasitoid established itself throughout the sugarcane region in Florida (1). *C. flavipes*, a small, gregarious parasitoid, was introduced from India during 1963 (1) and has also become established throughout the region. Both parasitoids are recognized as important natural enemies of the sugarcane borer in Florida. For example, Sosa (4) reported that, during 1981, 19 and 31% of the borers he collected were parasitized by *A. stigmatera* and *C. flavipes*, respectively. Also, natural control of borers by these parasitoids has been exploited in a pest management program (2). Although *A. stigmatera* and *C. flavipes* are recognized as important biological control agents of the sugarcane borer, the magnitude of their importance in Florida became clearer following a three year study on the seasonal activity of parasitoids against sugarcane borer larvae in sugarcane.

MATERIALS AND METHODS

Approximately 100,000 acres of commercial sugarcane grown by United States Sugar Corporation were scouted for sugarcane borers during 1982, 1983, and 1984. About 2,400 individual fields were scouted each year, and fields ranged from 33 to 80 acres in size. Six 3- or 4-scout crews, trained by U. S. Sugar's Agriculture Department to monitor infestation levels of the sugarcane borer, scouted fields once every three weeks from March through October or November. Four to eight locations in each field were usually scouted for borers on each sample date, and 25 stalks were examined for borers at each location. The scouts collected borers from whorls and leaf midribs, behind leaf sheaths, and inside stalks. Larvae were placed in containers with pieces of sugarcane and taken to U. S. Sugar's Research Department, where they were dissected to determine if parasitoids were present. Usually, around 500 larvae were dissected each week. Infestation levels of borers in each field scouted were calculated [% infestation level =# borers/# stalks examined * 100 (2)]. In order to study the seasonal activity of parasitoids against populations of the borer over time, records were maintained for each two-week period during 1982, 1983, and 1984 on the total number of borers collected and dissected and on the number of borers parasitized. Percentage parasitism levels were calculated and compared over time.

RESULTS AND DISCUSSION

Population dynamics of the sugarcane borer in Florida sugarcane were similar during 1982, 1983, and 1984. The overall infestation level of borers in infested fields averaged 3.4, 3.0, and 3.1% during the three years, respectively. Estimated infestation levels of borers in individual fields were sometimes in the 20 to 50% range (68% was the largest infestation level estimated for a single field on one sample date) but most infested fields had borer levels in the 1 to 5% range. There was little variation from month to month each year with respect to the overall infestation level of borers in infested fields (e.g., in 1984 the mean borer infestation level ranged from a low of 2.4% during May to a high of 3.8% during August). However, large increases occurred each year during March through October in the percentage of fields infested (e.g., in 1984 a mean of 9.7% fields were infested by borers during March through May while 26.4% fields were infested during August through September). Therefore, overall borer levels in Florida cane were low during spring but increased substantially over the summer each year.

Data collected on the percentage of borers parasitized over time indicated that larval parasitoids of the sugarcane borer were active continuously from early spring through late fall (Figure 1). The overall percentage of borer larvae parasitized during 1982, 1983, and 1984 was 33.1, 25.7, and 29.5%, respectively. The percentage of borers parasitized each season usually ranged from 5 to 20% during spring and early summer, and it steadily increased thereafter through late October. During 1982, population levels of parasitized borer larvae peaked in late October at 58%, dropped to 42% during early November, and then climbed to 76% during late November. Early season activity of parasitoids against borer larvae was greater during 1983 and 1984 than during 1982, but late season parasite activity tended to be less during 1983. Overall, the data collected during 1982, 1983, and 1984 showed the same trend in the seasonal activity of parasitoids against borers: low to moderate levels of biological control early during the season followed by large levels later during the season. Based on data from this study, biological control by parasitoids had a large impact against sugarcane borer populations after borer levels increased during late summer and fall in Florida. Although borer levels in individual sugarcane fields were sometimes reduced by parasitoids during July and August, overall borer levels across the sugarcane region in Florida were usually not reduced until September or later.

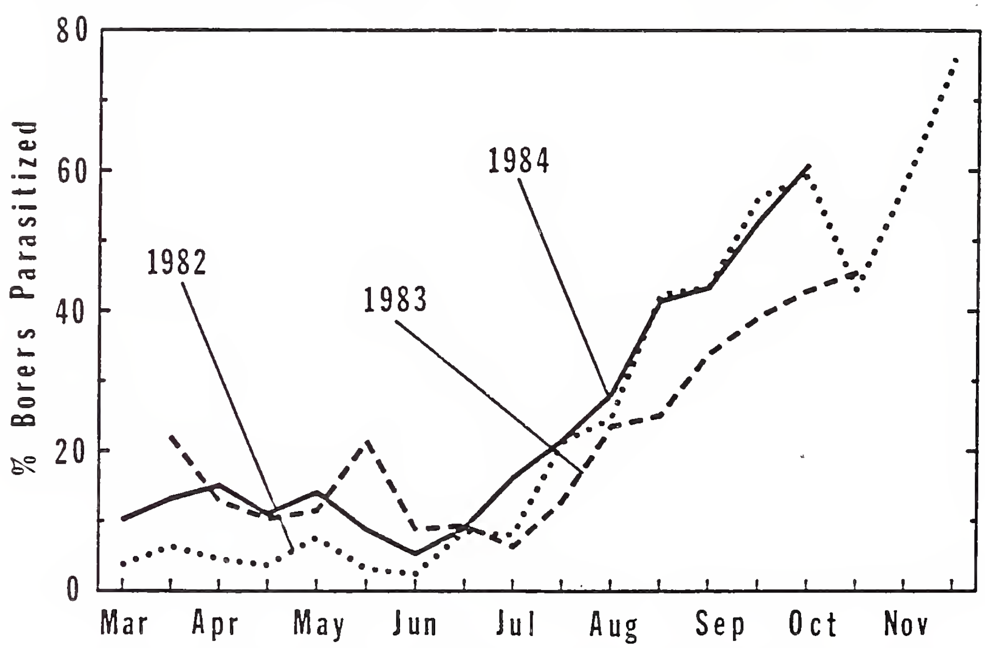

Figure 1. Seasonal activity of parasitoids (Agathis stigmatera and Cotesia flavipes) against sugarcane borer larvae in Florida based on the total percentage of borers parasitized during each two-week period in 1982, 1983 and 1984.

More than 25,000 sugarcane borers were collected by the scouts during the study. Although most of these borers were dissected to determine if parasitoids were present, parasitoids sometimes emerged and pupated before borers were dissected and adult parasitoids were obtained. In addition to the borers collected by scouts, many borer larvae were collected and held specifically to obtain adult parasitoids. Based on identifications of adult parasitoids and the shape, size, and appearance of immature parasitoids observed during dissections, A. stigmatera and C. flavipes were the only two important parasitoids of borer larvae in Florida sugarcane but other parasitoid species were present. For example, of 3,751 parasitized sugarcane borer larvae observed during 1984, 99.8% were parasitized by either A. stigmatera or C. flavipes; 6 of the 3,751 larvae were obviously parasitized by other unidentified, internal parasitoids (solitary), probably ichneumonids or braconids. No dipterous parasitoids were observed during the study.

The overall percentage of borer larvae parasitized by A. stigmatera during 1982, 1983, and 1984 was 4.9, 6.8, and 6.6%, respectively. Low to moderate population levels of A. stigmatera persisted from early spring through late fall each year (Figures 2, 3, 4). The overall percentage of borers parasitized by C. flavipes during the three years was 28.2, 18.9, and 22.9%, respectively. Few C. flavipes were usually active against borer larvae early during each growing season but, during mid-summer, population levels of C. flavipes began to increase and reached 40 to 55% by the end of October. Based on these mid to late season population levels, C. flavipes was an important mortality factor of sugarcane borers in Florida. Although late season population levels of A. stigmatera were comparatively much smaller, A. stigmatera was an important mortality factor because it was active throughout the year and especially since it was active early in the season.

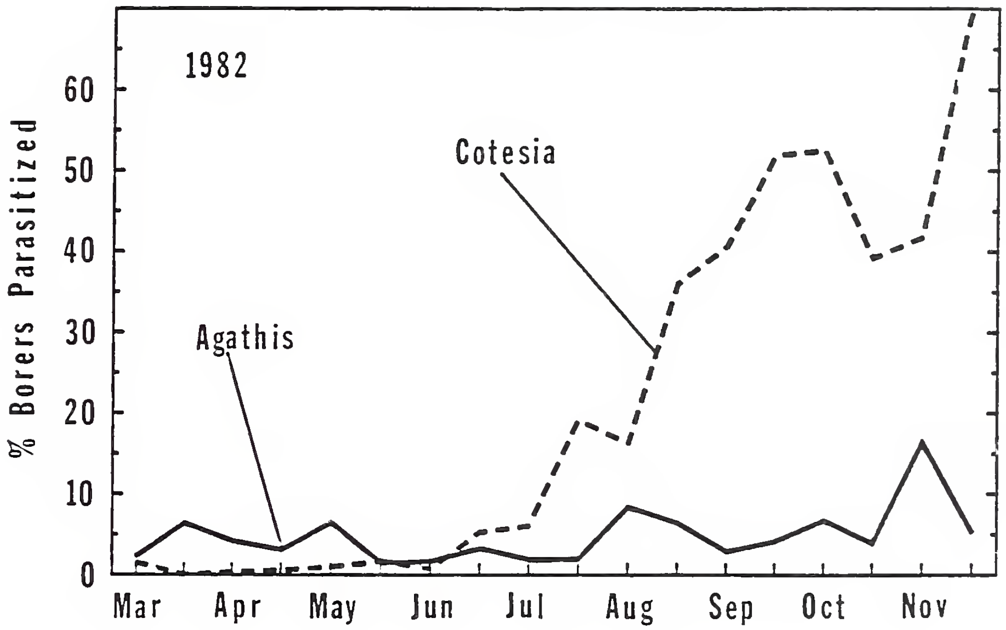

Figure 2. Activity of Agathis stigmatera and Cotesia flavipes against sugarcane borers in Florida during 1982.

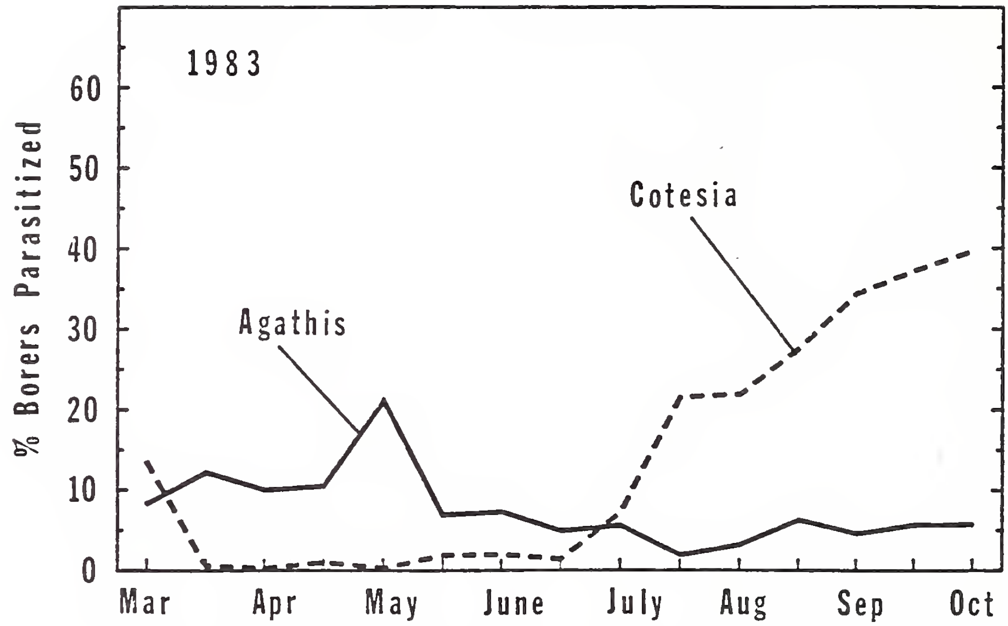

Figure 3. Activity of Agathis stigmater and Cotesia flavipes against sugarcane borers in Florida during 1983.

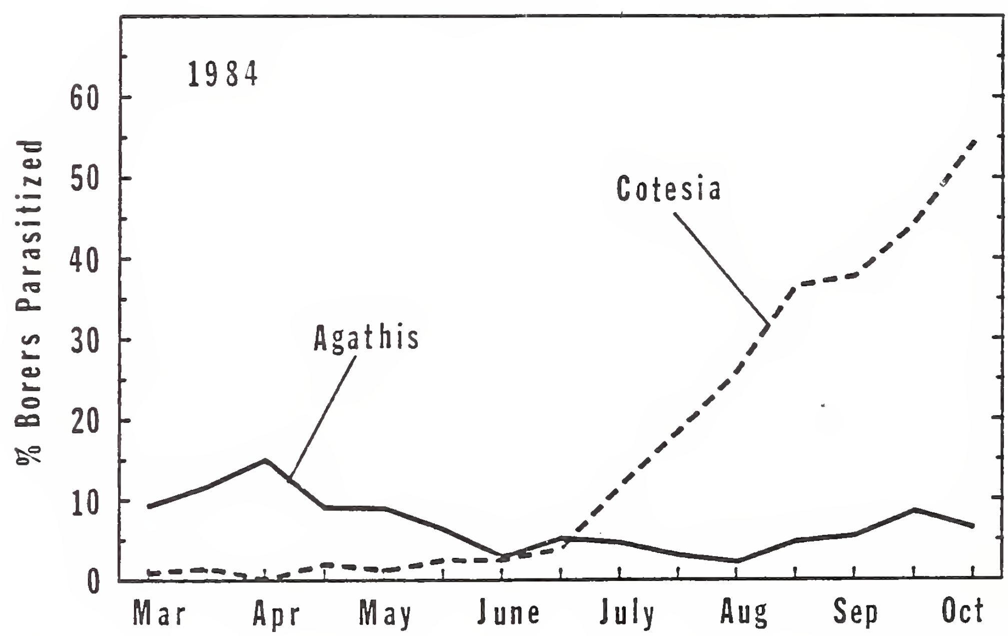

Figure 4. Activity of Agathis stigmatera and Cotesia flavipes against sugarcane borers in Florida during 1984.

ACKNOWLEDGMENTS

Adult specimens of *A. stigmatera* and *C. flavipes* were identified by P. M. Marsh, Systematic Entomology Laboratory, Insect Identification and Beneficial Insect Introduction Institute, USDA, Beltsville, MD.

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YIELD COMPARISON OF HEALTHY AND RATOON STUNTING DISEASE INFECTED CANE OF SIX COMMERCIAL SUGARCANE VARIETIES IN FLORIDA

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ABSTRACT

The effects of RSD on the agronomic yields of six sugarcane varieties were studied. In a test with two varieties in plant cane and first stubble, healthy cane averaged 0.95 and 0.35 points lower in early and late % yield 96^{o} sugar % cane (% yield), respectively, than diseased cane, but healthy cane produced 9.08 and 0.49 more metric tons/ha of cane and late sugar, respectively. There was no difference between healthy and infected cane in early tons of sugar/ha. In a test with six varieties in plant cane, healthy cane was 0.86 and 0.20 points lower in early and late % yield, respectively, than infected cane. However, healthy cane produced 13.58, 0.15, and 1.15 more tons/ha of cane, early sugar, and late sugar, respectively, than diseased cane. RSD significantly decreased the height and diameter of infected stalks of most varieties.

INTRODUCTION

Ratoon stunting disease (RSD) has been known to exist in Florida since the mid-1950's (Bourne and Hundertmark, unpublished). However, the extent of the disease and the magnitude of the losses it has caused are largely unknown. In two independent surveys conducted in commercial sugarcane fields during 1983 (2,6), it was determined that the RSD bacterium was very widespread in the Florida sugarcane industry with probably 75% or more of the commercial acreage infected. Due to the vast amount of infected cane, a study was conducted to determine the effect of RSD on the production of five of the major Florida commercial varieties.

MATERIALS AND METHODS

Test 1

A replicated test was established on organic soil in Palm Beach County, Florida, in October 1982. The test was arranged in a split-plot design with varieties as the main-plots and infection levels as the subplots. There were two varieties, CL 54-378 and CP 72-1210, and two infection levels, healthy and infected. Plot size was four rows (1.5 m spacing between rows) of 13.26 m length and there were five replications. Plots of healthy cane were established by directly hot water treating (2 hrs at 50^{o} C) the seedcane used to establish the plots; plots of infected cane were established using seed sources in which RSD had been detected by phase-contrast microscopy prior to use.

Data collected on the plant cane and first stubble crops included: early and late % yield 96^{o} sugar % cane (% yield), metric tons of cane per ha (TCH), and early and late metric tons of sugar per ha (ETSH and LTSH, respectively). Samples for juice analysis were taken by the core punch method (1) and used to estimate % yield. ETSH and LTSH estimates were calculated using the formula: ETSH or LTSH = (% yield/100)*TCH. In addition, for the first stubble crop, stalk diameter and stalk height data were collected on all plots. Stalk diameters were determined by measuring the diameter of the internodes of 10 stalks in the interior of each plot. The diameter of the internode closest to 1 m above ground level was measured to the nearest .01 cm using a vernier caliper. Stalk heights for 10 stalks were measured from ground level to the top visible dewlap. All stalk measurements were made on October 3, 1984, aproximately 8 months after the harvest of the plant cane crop.

The plant cane crop was harvested on February 8, 1984. The first stubble crop was harvested on March 12, 1985, approximately 13 months after the harvest of the plant cane crop. However, the cane growth was stopped by freezes on January 21 and 22, 1985, approximately 11.5 months after the previous harvest.

Test 2

A second replicated test was established on organic soil in Palm Beach County on September 28, 1983. Healthy and RSD infected plots of five Florida commercial varieties of unknown RSD susceptibility, CL 54-378, CL 59-1052, CL 61-620, CP 70-1133, and CP 72-1210, and one susceptible Louisiana variety, L 65-69, were included in the test. Plots of healthy cane were established using RSD-free seedcane obtained from the plant cane crop of propagation plots (hot water treated for 2 hrs at 50^{o} C) established in October 1982. RSD infected plots were established using seedcane from heavily infected propagation plots or from nearby commercial fields. In addition, seedpieces designated for the infected plots were inoculated immediately after cutting by immersion of the cut ends of the seedpieces in juice obtained from infected stalks. The test was arranged in a split-plot design with varieties as main-plots and infection levels (healthy and infected) as subplots; there were five replications and plot size was four rows (1.5 m row spacing) of 13.26 m length.

Data collected on the plant cane crop included: stalk diameter, stalk height, number of millable stalks/1.8 m of row, estimated number of millable stalks/plot, early and late % yield, TCH, ETSH, LTSH, and % infection/plot. Stalk heights and diameters were determined as described in Test 1. The number of millable stalks/1.8 m of row was determined in a single center row in the interior of the plot. The 1.8 m length of row was selected on the basis of appearing to contain normal sized stools for the plot and on the lack of gaps 1 m or more in length. The estimated number of millable stalks/plot was calculated using the number of stalks/1.8 m of row and the total number of meters per row without gaps of 1 m or more in the center two rows of each plot (stalks/m x no. of meters of row without gaps). All stalk measurements were made on August 1-8, 1984, approximately 10.5 months after the cane was planted. The plant cane crop was harvested on February 4-5, 1985.

Infection levels were determined during October 1984, by phase-contrast microscopy. Eight stalks, each from a different stool, were selected from the outside rows of each plot. A 2.0 x 1.5 cm (L x W) core was removed from the lowest intact internode of each stalk and centrifuged at 5,000 RPM (3015 x g) for 10 min. Phase-contrast optics were then used to examine 10 µl of the extracted sap for the presence of diagnostic RSD bacteria.

RESULTS

Test 1

Yield data from the plant cane and first stubble crops are summarized in Table 1. In plant cane, the healthy cane of both CL 54-378 and CP 72-1210 had lower early % yields (10/27/83) than the infected cane; averaged over both varieties, the difference was 0.80 points. At the late sampling date (1/12/84), the healthy cane averaged 0.61 points lower in % yield than the infected cane of both varieties. These differences were significant for both the early and late sampling dates. Healthy plots of CL 54-378 and CP 72-1210 produced 9.06 and 11.88 more TCH than the respective plots of infected cane. Averaged over both varieties, the healthy cane produced a significant 10.49 TCH more than the infected cane. There were no significant differences between treatments in ETSH and LTSH although the plots of healthy cane tended to be lower in ETSH and higher in LTSH than plots of infected cane.

In the first stubble crop, the healthy cane of both CL 54-378 and CP 72-1210 had significantly lower early % yields (11/2/84) than the infected cane; averaged over both varieties, the difference was 1.10 points. At the late sampling date (1/24/85), the healthy and diseased cane were not significantly different in % yield. Healthy CL 54-378 and CP 72-1210 averaged producing 5.72 and 9.64 more TCH than the respective infected cane. The increase in TCH was significant for CP 72-1210. When treatments were compared over both varieties, the healthy cane produced a significant 7.67 TCH more than the infected cane. There were no significant differences between treatments for the estimates of ETSH. Healthy CP 72-1210 produced significantly more LTSH (1.12 tons/ha) than the diseased cane; averaged over both varieties, healthy cane produced significantly more LTSH (0.80 tons/ha) than the diseased cane.

Table 1. Test 1 - Plant cane and first stubble yield data for healthy and RSD infected cane of two varieties.

Variety	Disease[1/] treatment	% Yield 96° sugar[2/] Early	Late	Tons of cane/ha[3/]	Tons of sugar/ha Early	Late
			Plant Cane			
CL 54-378	H	8.70	9.60	140.38	12.22	13.45
CL 54-378	I	9.63	10.04	131.32	12.64	13.18
H-I		-0.93*[4/]	- 0.44	+ 9.06	- 0.42	+ 0.27
CP 72-1210	H	8.45	10.10	170.71	14.41	17.26
CP 72-1210	I	9.12	10.84	158.83	14.48	17.19
H-I		-0.67	- 0.74*	+ 11.88	- 0.07	+ 0.07
Mean	H	8.58	9.83	155.56	13.34	15.36
Mean	I	9.38	10.44	146.07	13.61	15.18
H-I		-0.80*	- 0.61*	+ 10.49*	- 0.27	+ 0.18
			First Stubble			
CL 54-378	H	10.23	10.84	103.95	10.63	11.28
CL 54-378	I	11.37	10.99	98.23	11.16	10.78
H-I		- 1.14*	- 0.15	+ 5.72	- 0.53	+ 0.50
CP 72-1210	H	10.99	11.96	118.97	13.07	14.21
CP 72-1210	I	11.45	11.96	109.33	12.51	13.09
H-I		- 0.46*	0.00	+ 9.64*	+ 0.56	+ 1.12*
Mean	H	10.61	11.40	111.46	11.84	12.73
Mean	I	11.41	11.48	103.79	11.84	11.93
H-I		- 1.10*	- 0.08	+ 7.67*	0.00	+ 0.80*

[1/]H = healthy (hot water treated for 2 hrs at 50° C).
I = infected with RSD.

[2/]Plant cane early juice analyses were made on 10/27/83.
Plant cane late juice analyses were made on 1/12/84.
First stubble early juice analyses were made on 11/21/84.
First stubble late juice analyses were made on 1/24/85.

[3/]The plant cane crop was harvested on 2/8/84, approximately 12.5 months after planting. The first stubble crop was harvested on 3/13/85, approximately 13.0 months after the harvest of the plant cane crop.

[4/]* = significantly different at P=0.05% using Fisher's protected LSD test for the comparison of treatment means.

Stalks from healthy CL 54-378 were significantly taller (8.9 cm) and larger in diameter (0.13 cm) than infected stalks (Table 2). There were no significant differences between treatments for stalk height and diameter in CP 72-1210, although the healthy stalks tended to be slightly taller and thicker. Over both varieties, healthy stalks averaged 4.6 cm taller and a significant 0.08 cm thicker.

Test 2

Phase-contrast microscopy showed that the cane labeled as "infected" was heavily infected with RSD. All of the stalks examined of CL 59-1052, CL 61-620, and L 65-69 were infected, and over 90% of the stalks of CL 54-378, CP 70-1133, and CP 72-1210 were infected. All samples from the plots labeled as "healthy" were free of RSD.

Table 2. Mean stalk heights and diameters of healthy and RSD infected stalks in the first stubble crop of two sugarcane varieties.

Variety	Disease treatment1/	Stalk height (cm)2/	Stalk diameter (cm)3/
CL 54-378	H	284.2	2.92
CL 54-378	I	275.3	2.79
H-I		+ 8.9*4/	+0.13*
CP 72-1210	H	275.1	2.52
CP 72-1210	I	274.8	2.49
H-I		+ 0.3	+0.03
Mean	H	279.7	2.72
Mean	I	275.1	2.64
H-I		+ 4.6	+0.08*

1/H = healthy (hot water treated for 2 hrs at 50°C).
I = infected with RSD.

2/Stalk heights were determined on October 3-4, 1984, by measuring the distance from the ground level to the top visible dewlap of 10 stalks in the interior of the plots.

3/Stalk diameters of 10 stalks were measured at a height 1 m above the ground using a vernier caliper. Measurements were made on October 3-4, 1984, approximately 8 months after the harvest of the plant cane crop.

4/* = significantly different at P=0.05% using Fisher's protected LSD test for the comparison of treatment means.

As in Test 1, the early % yield (11/21/84) of the healthy cane was significantly lower than that of the infected cane for all varieties except CP 70-1133 (Table 3). Over all varieties, the early % yield of healthy cane was 0.86 points lower than that of infected cane. At the late sampling date, the healthy cane of five of six varieties averaged lower in % yield but the difference was significant in only CL 61-620. Plots of healthy cane averaged more TCH than plots of infected cane of all varieties. The increases on TCH for individual varieties were as follows: CL 54-378, 18.16; CL 59-1052, 23.98; CL 61-620, 9.55; CP 70-1133, 7.40; CP 72-1210, 10.79; and L 65-69, 11.64. All the increases were significant except that for CP 70-1133. When the treatments were compared over all varieties, the increase of 13.58 TCH in favor of the healthy cane was significant. The estimates of ETSH for all varieties except CL 59-1052 were not significantly different between treatments. For CL 59-1052, the healthy cane had an increase of 2.11 tons of sugar/ha (TSH) over the infected cane. At the late sampling date, the healthy cane of each variety averaged more sugar than the infected cane; however, the differences were not significant except in CL 59-1052. Averaged over all varieties, the healthy cane produced a significant increase of 1.15 LTSH over the infected cane.

On an individual stalk basis, the healthy cane of all varieties except CP 72-1210 had significantly taller stalks than the infected cane (Table 4). Over all varieties, the healthy stalks grew a significant 14.0 cm taller than the infected stalks. The healthy cane of all varieties except CP 70-1133 and CP 72-1210 was significantly thicker than the respective infected cane. Over all varieties, healthy stalks averaged 0.10 cm thicker than the infected stalks. There were no significant differences between treatments in any variety for the number of millable stalks/1.8 m of row or for the total number of millable stalks/plot, although there was a slight trend toward more stalks/plot in the healthy cane.

Table 3. Test 2 - Plant cane yield data for healthy and RSD infected cane of six varieties.

Variety	Disease treatment[1]	% Yield 96° sugar[2] Early	Late	Tons of cane/ha[3]	Tons of sugar/ha Early	Late
CL 54-378	H	9.70	9.82	142.13	13.79	13.97
CL 54-378	I	11.21	10.31	123.97	13.90	12.78
H-I		- 1.51*[4]	- 0.49	+18.16*	- 0.11	+ 1.19
CL 59-1052	H	11.65	11.95	166.00	19.35	19.84
CL 59-1052	I	12.14	11.51	142.02	17.24	16.34
H-I		- 0.49*	+ 0.44	+23.98*	+ 2.11*	+ 3.50*
CL 61-620	H	10.35	10.95	175.42	18.09	19.17
CL 61-620	I	11.52	11.52	165.87	19.10	19.10
H-I		- 1.17*	- 0.57**[5]	+ 9.55*	- 1.01	+ 0.07
CP 70-1133	H	10.03	9.97	159.46	15.96	15.87
CP 70-1133	I	10.31	10.26	152.06	15.67	15.60
H-I		- 0.28	- 0.29	+ 7.40	+ 0.29	+ 0.27
CP 72-1210	H	10.51	11.40	178.09	18.70	20.27
CP 72-1210	I	11.34	11.44	167.30	18.99	19.12
H-I		- 0.83*	- 0.04	+10.79*	- 0.29	+ 1.15
L 65-69	H	10.10	9.08	139.15	14.06	12.62
L 65-69	I	11.00	9.35	127.51	14.01	11.90
H-I		- 0.90*	- 0.27	+11.64*	+ 0.05	+ 0.72
Mean	H	10.39	10.53	160.04	16.63	16.86
Mean	I	11.25	10.73	146.46	16.48	15.71
H-I		- 0.86*	- 0.20	+13.58*	+ 0.15	+ 1.15*

[1]H = healthy seedcane was obtained from the plant cane crop of plots which had been planted with hot water treated cane (50°C for 2 hr).
I = infected with RSD.

[2]Early juice analyses were made on 11/21/84.
Late juice analyses were made on 1/24/85.

[3]All plots were harvested on 2/4-5/85.

[4]* = significantly different at P=0.05% using Fisher's protected LSD test for the comparison of treatment means.

[5]** = significantly different at P=0.05% using Fisher's unprotected LSD test for the comparison of treatment means.

DISCUSSION

Although RSD has been known to exist in Florida for many years, little attention was paid to the disease until the causal organism was identified (3) and a rapid and reliable method to detect the organism was developed (4). It was also unkown if RSD, caused by a xylem limited bacterium, would influence crop yields under Florida conditions since most of the sugarcane is grown on organic soils that generally supply adequate soil moisture. However, in the two tests presented here conducted during years of above average rainfall (1983=130.5 cm, 1984=125.9 cm, 13 yr average from 1972-1984=118.cm), the healthy cane produced significantly more cane tonnage than the infected cane. On the other hand, RSD significantly increased early % yield in all but one variety. The net effect of RSD-free cane early in the season was non-significant differences in early sugar production due to the offsetting effects of lower % yield and increased TCH in healthy cane. At the late sampling date, the % yields of the healthy cane tended to be lower, but this tendency was more than offset by higher cane tonnage. Therefore, the net effect of healthy cane at the late sampling date was significantly higher sugar production. Over all varieties, late sugar production was increased by 1.15 and 0.80 TSH in Tests 2 and 1, respectively.

Table 4. Mean stalk heights, diameters, stalks per 6 ft of row, and estimated number of stalks per plot for healthy and RSD infected cane of 6 varieties.

Variety	Disease treatment1/	Stalk height (cm)2/	Stalk diameter (cm)3/	Number of stalks per 1.8 m of row4/	Estimated number of stalks in center 2 rows5/
CL 54-378	H	254.6	3.12	21.6	301.0
CL 54-378	I	234.5	3.00	20.2	284.4
H-I		+ 20.1*6/	+ 0.12*	+ 1.4	+ 16.6
CL 59-1052	H	223.3	3.22	25.2	333.7
CL 59-1052	I	208.0	3.08	27.0	312.3
H-I		+ 15.2*	+ 0.14*	- 1.8	+ 21.4
CL 61-620	H	232.1	2.95	30.8	446.6
CL 61-620	I	217.7	2.79	30.8	446.6
H-I		+ 14.4*	+ 0.16*	0.0	0.0
CP 70-1133	H	279.2	2.60	29.4	426.3
CP 70-1133	I	266.8	2.56	26.2	377.5
H-I		+ 12.4*	+ 0.04	+ 3.2	+ 48.8
CP 72-1210	H	250.2	2.68	30.0	431.5
CP 72-1210	I	246.4	2.64	28.2	408.9
H-I		+ 3.8	+ 0.04	+ 1.8	+ 22.6
L 65-69	H	289.2	2.48	29.2	423.4
L 65-69	I	271.1	2.37	29.4	412.6
H-I		+ 18.1*	+ 0.11*	- 0.2	+ 10.8
Mean	H	254.8	2.84	27.7	393.7
Mean	I	240.8	2.74	27.0	373.7
H-I		+ 14.0*	+ 0.10*	+ 0.7	+ 20.0

1/H = healthy seedcane was obtained from the plant cane crop of plots which had been planted with hot water treated cane (2 hrs at 50° C).
I = infected with RSD.

2/Stalk heights were determined on August 1-8, 1984, by measuring the distance from the ground level to the top visible dewlap of 10 stalks in the interior of the plots.

3/Stalk diameters of the same 10 stalks used for the height determinations were measured at a height 1 m above the ground using a vernier caliper. Diameters were measured to the nearest 0.01 cm.

4/The number of stalks per 1.8 m of row was determined on 1.8 m of row on the interior portion of 1 of the 2 center rows.

5/The number of stalks in the center 2 rows was estimated using the number of stalks/1.8 m of row and the total number of meters of row without gaps.

6/* = significantly different at P=0.05% using Fisher's protected LSD test for comparison of treatment means.

When the yield data is expressed as the percentage increase or decrease of the healthy cane over the infected cane (Table 5), the trends of the data and the benefits of healthy cane can readily be seen. Over all varieties in both tests, the healthy plant cane was 7.9% and 2.9% lower in early and late % yield, respectively, than the infected cane; however, the healthy cane was 9.0%, 0.4%, and 5.9% higher in TCH, ETSH, and LTSH, respectively. The healthy stubble cane of two varieties was 6.9% and 0.7% lower in early and late % yield, respectively, than the infected cane, and 7.4%, 0.2%, and 6.8% higher in TCH, ETSH, and LTSH, respectively. CL 59-1052 was the variety most improved by healthy seedcane with increases of 16.9%, 12.2%, and 21.4% in TCH, ETSH, and LTSH, respectively. All

varieties responded to the therapeutic hot water treatments by producing more TCH. This increase in TCH in most cases partially made up for the lower early % yield. As the healthy cane continued to mature, the increased TCH and the equal to slightly lower late % yield in healthy cane resulted in an overall LTSA increase of 0.4% to 21.4% within an individual variety.

Table 5. Summary of the yield data for tests 1 and 2 presented as a percentage increase or decrease of the healthy cane compared to the infected cane.

		% Increase (+) or decrease (-) of healthy cane compared to infected cane				
Variety	Test No.	Early % yield	Late % yield	Tons of cane/ha	Early tons sugar/ha	Late tons sugar/ha
			Plant Cane			
CL 54-378	1	- 9.7	- 4.4	+ 6.9	- 3.4	+ 2.0
CL 54-378	2	-13.5	- 4.8	+14.6	- 0.8	+ 9.3
CL 59-1052	2	- 4.0	+ 3.8	+16.9	+12.2	+21.4
CL 61-620	2	-10.2	- 4.9	+ 5.8	- 5.3	+ 0.4
CP 70-1133	2	- 2.7	- 2.8	+ 4.9	+ 1.9	+ 1.7
CP 72-1210	1	- 7.3	- 6.8	+ 7.5	- 0.5	+ 0.4
CP 72-1210	2	- 7.3	- 0.3	+ 6.4	- 1.5	+ 6.0
L 65-69	2	- 8.2	- 2.9	+ 9.1	+ 0.3	+ 6.0
Mean		- 7.9	- 2.9	+ 9.0	+ 0.4	+ 5.9
			Stubble Cane			
CL 54-378	1	-10.0	- 1.4	+ 5.8	- 4.8	+ 4.6
CP 72-1210	1	- 4.0	0.0	+ 8.8	+ 4.5	+ 8.6
Mean		- 6.9	- 0.7	+ 7.4	- 0.2	+ 6.8

The losses in cane tonnage attributed to RSD were apparently due to a reduction in stalk height and diameter and not to a reduction in the total number of stalks. The trend towards more stalks/plot in the healthy cane was probably not due to a higher number of stalks/stool but instead due to a slightly better stand, i.e., more stools/plot. The data collected agrees with the observations by Hughes (5), that RSD caused slow and erratic germination and a reduction in stalk height and diameter.

After the harvest of two crops in a test with two varieties and the harvest of one crop in a test with six varieties, it is apparent that RSD is capable of causing substantial losses in production during average growing seasons. Since RSD is considered to be more of a problem in stubble crops (5,8) and can increase the sensitivity of varieties to drought stress (5,7,8,9), RSD could possibly cause yield losses considerably greater than presented here.

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YIELD LOSSES IN SUGARCANE VARIETY CL 65-260 DUE TO SUGARCANE SMUT IN FLORIDA

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ABSTRACT

Yield data were collected from 24 plots of CL 65-260 infected with different levels of sugarcane smut. When yield data were regressed on % stalk and % stool infection data, regression coefficients indicated that percent stalk infection was better than percent stool infection as an indicator of yield losses due to smut infection. In the plant cane crop, cane tonnage dropped 0.46 metric tons/ha for each 1% stalk infection or 0.66 tons/ha for each 1% stool infection. Sugar production dropped 0.045 tons/ha for each 1% stalk infection or 0.06 tons/ha for each 1% stool infection.

INTRODUCTION

Since it was discovered in Florida in 1978, sugarcane smut (Ustilago scitaminea Syd.) has had a major impact on the Florida sugar industry. At least 9 commercial varieties (8 CL and 1 CP varieties) are being or have been phased out of commercial production due to smut susceptibility. In addition, many high yielding unreleased clones have been eliminated from the United States Department of Agriculture and United States Sugar Corporation breeding and selection programs due to smut susceptibility.

Economic losses around the world due to smut have been reported to range from negligible to up to 73% by Antoine (2). Holder (6) estimated that smut rapidly caused a 33-34% decline in the production of 2 highly susceptible varieties in Florida from one year to the next. This estimate was obtained from fields with a high level of natural infection, and no attempt was made to predict yield losses due to different levels of smut infection.

During 1984, a test involving artificial inoculations was conducted to obtain yield loss estimates for different levels of smut infection.

MATERIALS AND METHODS

A test with one clone and six levels of smut treatments was established on organic soil in Palm Beach County, Florida, on January 19 and 20, 1984. The experimental design was a randomized complete-block with six treatments and four replications. The clone studied was CL 65-260, which has been rated as susceptible (rating = 7 where, 1 = resistant and 9 = very susceptible) to smut (Irey, unpublished data). Plot size was two rows (1.5 m row spacing) of 13.26 m length with one untreated row on each side of the plot. One hundred and six 3-4 bud seedpieces were used to plant each plot.

Shoot counts were made on March 14, 1984, to determine the number of emerged primary shoots/plot. On March 16-19, 1984, the proper number of shoots were inoculated to establish plots where 0, 10, 20, 40, 70 and 100% of the available shoots in each plot were inoculated. The shoots were inoculated by injecting 0.5 ml of a freshly prepared teliospore suspension containing approximately 5×10^4 viable teliospores/ml into the emerged shoots just above the apical meristem. Whenever possible, shoots 15 to 30 cm in height were used for the inoculations. Previous work (Irey, unpublished data) had indicated that shoots of this size were easily infected by the inoculation procedure. In the highest smut inoculation treatments, it was necessary to inoculate shoots both smaller than 15 cm and larger than 30 cm. The seedcane used for the plots in which 0% of the shoots were inoculated received a hotwater treatment of 52°C for 30 min prior to use to eliminate systemic smut infection and surface contamination.

The following data were collected during the plant cane crop: % infected stools, % infected stalks, early and late yield 96° sugar % cane (% yield), metric tons of cane/ha (TCH), and early and late metric tons of sugar/ha (TSH). Smut infections were identified by the presence of a whiplike structure at the stalk apex characteristic of diseased stalks (2). The percentage of infected stools/plot was determined by comparing the number of infected stools to the original number of primary shoots counted in March. The determination as to what comprised an individual stool was made visually. The percentage of infected stalks/plot was determined

by comparing the total number of infected stalks to the total number of stalks/plot (number of millable healthy stalks plus the number of infected stalks). Millable stalk counts were made on August 6, 1984. Samples for the early and late juice analysis were taken by the core punch method (3) and used to estimate early and late % yield. Early samples were taken on November 1, 1984; late samples were taken on January 30, 1985. All plots were harvested on February 4, 1985. Early and late tons of sugar/ha (ETSH and LTSH, respectively) estimates were made using the formula: TSH = (% yield/100)*TCH. Yield reductions in relation to smut infection were determined from simple linear regressions comparing plot % yield, TCH, and TSH, to the percentage of infected stools and the percentage of infected stalks.

RESULTS AND DISCUSSION

Based on the shoot counts made in March, a mean of 128.0 to 170.3 primary shoots/plot emerged for each of the smut inoculation treatments (Table 1). A mean of 14.8 to 148.0 shoots were inoculated/plot in the lowest to highest inoculation treatments, respectively. Based on data collected in July, primary infection levels achieved from the combined effects of natural infection, systemic seedpiece infection and the artificial inoculations ranged from 0 to 32.7% infected stools/plot and 0 to 58% infected stalks/plot (Table 2). No attempt was made to identify the source of smut infection, (systemically infected seedpiece, natural infection, or successful inoculation) since the desired result of the inoculation treatments was to establish different levels of smut infection regardless of the source of infection.

Table 1. Mean number of emerged and inoculated shoots per plot in the plant cane crop of CL 65-260.

Treatment	Mean number of emerged shoots/plot[1/]	Mean number of inoculated shoots/plot[2/]
0% inoculation	147.0	0
10% inoculation	145.0	14.8
20% inoculation	128.0	25.5
40% inoculation	170.3	68.0
70% inoculation	138.5	97.3
100% inoculation	148.0	148.0

[1/] Plots were planted on 1/19-20/84. The number of emerged primary shoots was determined on 3/14/84.

[2/] Shoots were inoculated on 3/19/84 by injecting 0.5 ml of freshly prepared teliospore suspension containing approximately 5 x 10^4 viable teliospores/ml into the emerged shoots just above the apical meristem.

Table 2. Smut infection of CL 65-260 in the plant cane crop in response to 6 different inoculation treatments.

Variety	Treatment applied[1/]	% Stools infected[2/]		% Stalks infected[3/]	
		Average	Range	Average	Range
CL 65-260	0%	0	0	0	0
CL 65-260	10%	8.4	6.9-12.2	21.1	17.2-30.8
CL 65-260	20%	11.3	10.1-12.5	22.6	17.5-25.5
CL 65-260	40%	20.1	16.4-23.8	38.6	27.2-45.3
CL 65-260	70%	18.7	11.7-24.3	32.8	19.5-38.8
CL 65-260	100%	25.7	21.4-32.7	41.3	30.9-58.0

[1/] 0% = Hot water treated for 30 min at 52°C.
10% = 10% of all emerged shoots inoculated by the injection of 0.5 ml of a teliospore suspension containing 5 x 10^4 viable teliospores/ml.
20% = 20% of all emerged shoots inoculated as above.
40% = 40% of all emerged shoots inoculated as above.
70% = 70% of all emerged shoots inoculated as above.
100% = 100% of all emerged shoots inoculated as above.

[2/] % Stools infected = (No. infected stools/No. primary shoots) * 100.

[3/] % Stalks infected = (No. infected stalks/[No. infected stalks + No. healthy millable stalks]) * 100.

The infection levels obtained were quite variable within the applied treatments, especially at the higher inoculation levels. For example, in the 70% inoculation treatment, the infection levels achieved in the four replications ranged from 11.4 to 24.3% infected stools/plot and from 19.5 to 38.8% infected stalks/plot. In addition, increased inoculation percentage did not give increased infection in some treatments or replications. For example, the infection levels achieved in the 40% inoculation treatment were higher than those achieved in the 70% inoculation treatment on both a % stools and % stalks infected basis. The variability of the infection levels within and between the smut treatments was most likely due to the varying efficiency of the inoculation method. In the lower inoculation treatments (10 and 20% inoculation treatments), it was possible to select shoots of the proper size to achieve infection; hence, the inoculation efficiency was relatively high. In the higher inoculation treatments (40, 70 and 100% inoculation treatments), shoots of all sizes were inoculated and the efficiency of the method was apparently reduced.

Due to the variability in smut infection within treatments, no significant yield differences were found among the smut treatments by analysis of variance. Regression analysis using data from all 24 plots showed that TCH was significantly correlated with smut infection and that TCH was reduced by 0.46 and 0.66 tons/ha for each 1% stalk or 1% stool infection, respectively (Figures 1 and 2). Percentage stalk infection was a better indicator ($r = -.61$, $P = .001$) of TCH loss due to smut infection than was percentage stool infection ($r = -.52$, $P = .009$). These production figures were collected on plots that averaged 98.86 TCH over the whole experiment. No significant linear relationships were evident between early or late % yield and % stalk infection or % stool infection. Consequently, the regression equations obtained for ETSH and LTSH (Figures 3 and 4) reflect the reductions in cane tonnage due to smut infection. For each 1% stalk infection, early and late sugar production decreased 0.04 and 0.05 TSH respectively; for each 1% stool infection, sugar production decreased by 0.06 TSH. As with TCH, % stalk infection was a better indicator of losses in TSH due to smut infection than was % stool infection.

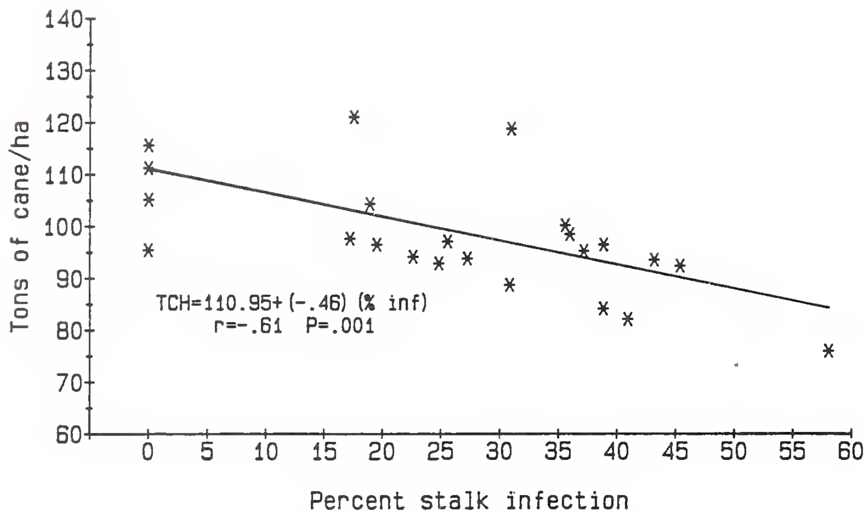

Figure 1. Regression of tons of cane/ha on % stalk infection.

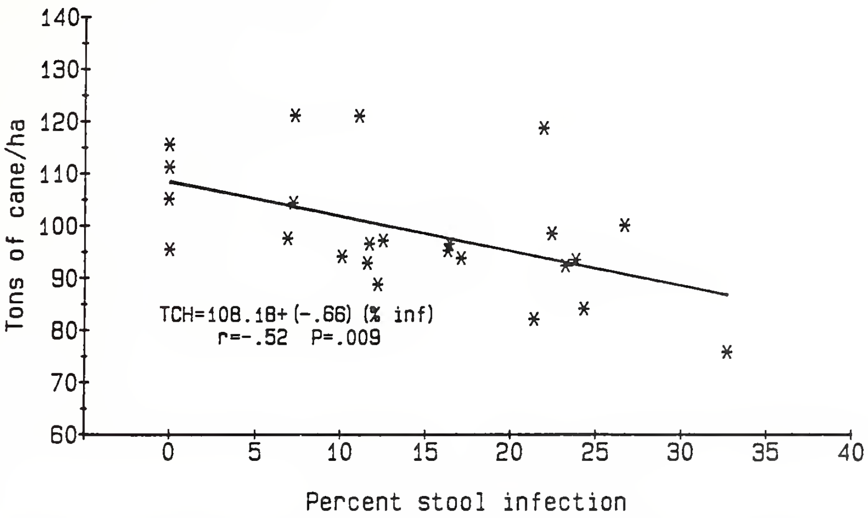

Figure 2. Regression of tons of cane/ha on % stool infection.

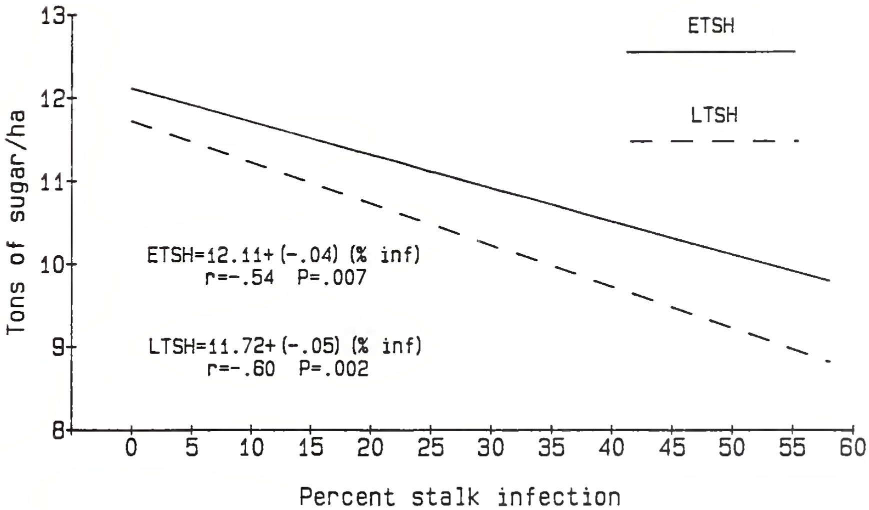

Figure 3. Regression of tons of sugar/ha on % stalk infection.

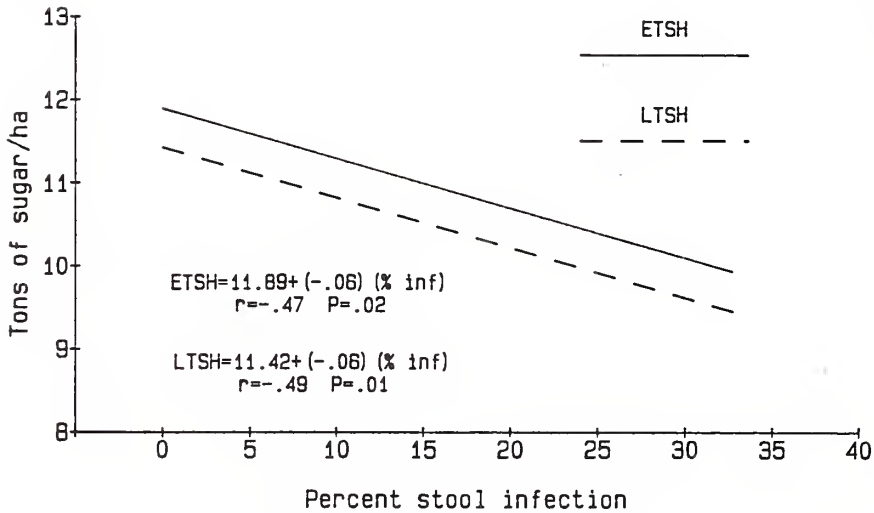

Figure 4. Regression of tons of sugar/ha on % stool infection.

The reaction of a particular variety to smut infection may be different than the reaction of another variety under similar conditions (4, 5); thus, the figures presented here may be applicable only to CL 65-260. Similar experiments conducted in Colombia with CP 57-603 (1) and in Louisiana with CP 73-351(7) have shown that for each 1% stalk infection, cane tonnage decreased 1.1 and 0.6 TCH respectively. Although most of the very susceptible varieties have been rotated out of production, several of the major commercial varieties in Florida are moderately susceptible to smut. An effort should be made to plant these varieties in areas of low disease pressure and to use seed sources with a low incidence of smut infection.

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FEASIBILITY OF USING LAYBY APPLICATION OF HERBICIDES FOR WEED CONTROL AND YIELD ENHANCEMENT IN SUGARCANE

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ABSTRACT

Studies in Louisiana during a standard three year sugarcane (Saccharum interspecific hybrids) cropping cycle determined the feasibility of using layby application of herbicides as a weed control strategy in sugarcane. In general, herbicide treatments applied both in spring and at layby resulted in weed control superior to treatments applied only in the spring. The best herbicide treatments for overall weed control were metribuzin (4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one) applied at 1.7 + 1.7 kg/ha spring + layby, terbacil (5-chloro-3-(1,1-dimethylethyl)-6-methyl-2,4(1H,3H)-pyrimidinedione) applied at 1.1 + 1.1 kg/ha at spring + layby, or metribuzin applied at 2.2 kg/ha in the spring followed by a layby application of ametryn (N-ethyl-N'-(1-methylethyl)-6-(methylthio)-1,3,5-triazine-2,4-diamine) at 2.2 kg/ha, paraquat (1,1'-dimethyl-4,4'-bipyridinium ion) at 0.6 kg/ha, or asulam (methyl[(4-aminophenyl)sulfonyl]carbamate) at 3.7 kg/ha. Although most layby treatments effectively controlled weeds, sugarcane yields were not increased as compared to spring only treatments. Thus, during a three-year cropping cycle, layby application of herbicides may not be required unless heavy weed infestations are present.

INTRODUCTION

Sugarcane growers in Louisiana often choose to include application of herbicides at layby (at or immediately following the last cultivation) in their weed management program. Although excellent weed control often results, little research has been conducted to determine the feasibility of using layby applications of herbicides in sugarcane. Osgoode, et al. (8) examined the effect of postemergence directed applications of ametryn and diuron (N'-(3,4-dichlorophenyl)-N,N-dimethylurea) on the yield of sugarcane cultivars in a weed-free environment. In general, the herbicides caused a reduction in the height, stem diameter, and tillering of the sugarcane. However, the benefits of weed control could not be assessed against the risks of phytotoxicity to the plants.

Millhollon (6) investigated the use of trifluralin (2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl)benzenamine), EPTC (S-ethyldipropylcarbamothioate), fenac (2,3,6-trichlorobenzeneacetic acid), and terbacil as layby treatments in sugarcane. The research observed benefits derived from layby treatments during a one-year period and not a three-year cropping cycle. The general conclusion of the study was that layby herbicide applications did not improve yields except where itchgrass was a major weed.

Most research concerning use of layby and directed application of herbicides has been conducted in crops other than sugarcane, especially cotton (Gossypium hirsutum L.) and corn (Zea mays L.). In many cases, layby herbicide application appeared to be a feasible alternative. As early as 1953, researchers found that late season weed competition in cotton resulted in decreased cotton grade, and diminished profits to the grower (3). Other researchers argued that directed applications of herbicides may lower costs, lower application rates of herbicides, decrease herbicide residues, and improve weed control, but may be difficult to schedule on large acreages and may pose possible injury problems if the herbicide is applied improperly (4). Miller and Carter (5) found that a layby application of dinitrobenzamine herbicides preceded by no preemergence treatment did not improve yields over that of the untreated plot. Directed applications of dalapon (2,2-dichloropropionic acid) in cotton at layby were not detrimental to the crop (3). In Louisiana grown cotton, layby treatments gave excellent weed control, but did not improve yields or decrease pre-harvest losses, harvest losses, and wagon trash (9). The value of layby treatments was thus considered questionable.

A large study was conducted by Moomaw et al. (7) in Nebraska to investigate the use of layby herbicide applications in irrigated corn. Although some of the

layby treatments reduced crabgrass (Digitaria sanguinalis (L.) Scop.) populations and seed production, layby application did not improve yields compared to the standard treatment of a preemergence application of atrazine (6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine) plus alachlor (2-chloro-N-(2,6-diethylphenyl)-N-methoxymethyl)acetamide). At another location, corn yields were not increased by layby treatments primarily due to the lack of improvement of weed control.

Thus, past research in annual crops would indicate that layby herbicide applications in sugarcane may not improve yield. However, the growing season of sugarcane is much longer than most crops. In addition, sugarcane is a perennial crop grown over a three-year cycle. Therefore, late emerging weeds may potentially cause yield reductions in subsequent stubble crops. A study was initiated in two locations in south Louisiana to investigate the feasibility of utilizing layby application of herbicides for weed control and yield enhancement in sugarcane over a three-year cropping cycle.

MATERIALS AND METHODS

Research sites were located in south Louisiana near Paincourtville and Rougon. The Paincourtville site was typified by a Commerce silty clay loam with a pH of 6.3 and 1.30% organic matter. The Rougon site was characterized by a Commerce silt loam with a pH of 4.9 and 0.93% organic matter. Both sites were treated with 1.1 kg/ha terbacil on a 0.9 m band following planting of sugarcane in the fall of 1980.

Herbicides were applied using a CO_2-pressurized backpack sprayer calibrated at 200 L/ha for spring applications and 100 L/ha for layby applications. Spring treatments were applied on a 0.9 m band directly overtop of the sugarcane. Layby treatments were broadcast directed applications, allowing spray to contact only the lower 0.3 m of the sugarcane. Weeds were controlled between the crop rows with cultivation prior to layby treatments. Specific dates of herbicide application are listed in Table 1.

Table 1. Height[1/] of sugarcane at each date of application of spring and layby treatments of various herbicides near Rougon and Paincourtville, Louisiana.

Crop/Location	Spring Date	Spring Height (cm)	Layby Date	Layby Height (cm)
Rougon (CP 70-321)				
Plant cane	Apr 1	6	June 19	150
First stubble	Apr 1	6	June 30	120
Second stubble	Mar 29	6	July 8	150
Paincourtville (CP 65-357)				
Plant cane	Mar 12	6	June 29	110
First stubble	Mar 29	6	June 25	40[2/]
Second stubble	Apr 13	6	July 7	120

1/Distance from the ground surface to the uppermost visible dewlap.

2/Due to dry conditions, sugarcane height was reduced at this location.

Weed control was evaluated in the early spring and late summer by visually estimating the foliar cover of individual weed species as described by Conn et al. (1). Foliar cover indicates the percentage of the ground surface covered by live, green plant tissue. Overall weed foliar cover was calculated as the sum of the foliar cover of each individual species.

In 1981 and 1982, sugarcane was hand-harvested except in Rougon in 1982 when plots were not harvestable. Stalks were cut at the ground surface, topped approximately 15 cm below the apical meristem, and stripped of leaves. A 10-stalk sample was randomly selected from each plot and weighed for an estimation of mean stalk weight, and a 5-stalk subsample was transported to the laboratory for determination of sucrose content (10). Sucrose content was not determined in 1982. In 1983, plots were machine harvested and a 50-stalk subsample was used to estimate mean stalk weight. Sucrose content was determined as described for 1981. Yields were determined as kg of cane/ha by multiplying the stalks/ha X kg/stalk. Sugar yield was then estimated as g sugar/kg of cane X kg cane/ha.

The experiments were randomized complete block designs with four replicates per treatment. Data for locations were combined where possible and analyzed statistically. *A priori* comparisons were made to contrast overall spring plus layby treatments, spring applications, and the untreated control.

RESULTS AND DISCUSSION

Weed control was greatly enhanced by the addition of layby treatments throughout the duration of the experiment as indicated by the foliar cover of weeds in each crop (Table 2). The foliar cover of weeds on the untreated plots was 68% in the plant cane year and did not increase above that level throughout the entire cropping cycle. A spring herbicide application alone resulted in 24% total foliar cover in the plant cane year and increased to 41% by second stubble. A layby treatment following the spring treatment resulted in 4-13% foliar cover of weeds during the cropping cycle. The exact performance of individual herbicide treatments often varied from this average.

Table 2. Total foliar cover of weeds at two locations during a 3-year sugarcane crop as affected by spring or spring plus layby herbicide application.

Application time	Crop and date evaluated		
	Plant cane August 1981	First stubble August 1982	Second stubble May 1983
	Foliar cover (%)		
Untreated	68 a[1/]	63 a	64 a
Spring only[2/]	24 b	33 b	41 b
Spring and layby[3/]	4 c	8 c	13 c

[1/]Means within the same column followed by the same letter are not significantly different according to *a priori* contrasts at the 95% level of confidence.

[2/]Averaged across the following treatments: (1) fenac at 3.0 kg/ha, (2) terbacil at 1.7 kg/ha, and (3) metribuzin at 2.7 kg/ha.

[3/]Averaged across the following spring and layby treatments: (1) terbacil + terbacil (1.1 + 1.1 kg/ha), (2) fenac + fenac (1.7 + 1.7 kg/ha), (3) metribuzin + metribuzin (1.7 + 1.7 kg/ha), (4) metribuzin + ametryn (2.2 + 2.2 kg/ha), (5) metribuzin + paraquat (2.2 + 0.6 kg/ha), and (6) metribuzin + asulam (2.2 + 3.7 kg/ha).

Major weed species encountered in August, 1983, in second stubble at the Paincourtville location (Table 3) were sprawling panicum (*Urochloa reptans* (L.) Stapf.), johnsongrass (*Sorghum halepense* (L.) Pers.), and junglerice (*Echinochloa colonum* (L.) Link). All treatments provided excellent control of sprawling panicum with the exception of a spring application of terbacil or metribuzin. This species generally germinates in late spring when residues from the two compounds were probably not sufficient for control. No differences in johnsongrass control were observed between treated plots and untreated plots, but the infestation was variable. Broadleaf signalgrass was not observed in untreated plots probably due to high populations of other weeds. With the exception of fenac, the addition of layby treatments resulted in improved control of junglerice, a late germinating grass.

The least effective overall weed control programs at this location included a spring application of terbacil at 1.7 kg/ha or metribuzin at 2.7 kg/ha which gave 56% and 47% total weed control, respectively, and fenac applied in the spring at 3.0 kg/ha or a split application of fenac at 1.7 kg/ha in spring and at layby which gave 78% weed control. A split application of terbacil at 1.1 kg/ha resulted in weed control superior to terbacil applied only in the spring at 1.7 kg/ha. A split application of metribuzin at 1.7 kg/ha resulted in excellent weed control and proved to be more effective than metribuzin applied in the spring at 2.7 kg/ha. Metribuzin applied in the spring at 2.2 kg/ha followed by ametryn, paraquat, or asulam resulted in excellent weed control. In general, layby treatments at the Paincourtville location resulted in improved weed control, with the exception of fenac.

Table 3. Foliar cover of various weed species on August 9, 1983, in second stubble following three consecutive years of spring only or spring + layby herbicide treatments near Paincourtville, Louisiana.

Herbicide treatment and rate				Major weed species present[4]			
Spring		Layby		PANRP	SORHA	ECHCO	Total
(kg/ha)		(kg/ha)		Foliar cover (%)			
Untreated	---	---	---	59 a[1]	46 a	16 ab	133 a
Fenac	3.0	---	---	6 b	13 a	6 bcd	29 cd
Fenac	1.7	Fenac	1.7	1 b	9 a	18 a	28 cd
Terbacil	1.7	---	---	40 a	10 a	8 abcd	58 bc
Terbacil	1.1	Terbacil	1.1	2 b	8 a	3 cd	13 d
Metribuzin	2.7	---	---	39 a	19 a	14 abc	71 b
Metribuzin	1.7	Metribuzin	1.7	1 b	1 a	0 d	1 d
Metribuzin	2.2	Ametryn[2]	2.2	1 b	1 a	2 d	3 d
Metribuzin	2.2	Paraquat[3]	0.6	0 b	14 a	1 d	15 d
Metribuzin	2.2	Asulam[3]	3.7	1 b	3 a	1 d	6 d

1/Means within the same column followed by the same letter are not significantly different according to Duncan's New Multiple Range Test at the 95% level of confidence.

2/Plus 1% v/v Atplus 411F.

3/Plus 0.5% v/v X-77.

4/PANRP: Sprawling panicum; SORHA: Johnsongrass; ECHCO: Junglerice.

At the Rougon location, a very diverse weed population was observed in March, 1983, in second stubble (Table 4). Dominant weed species included sowthistle (*Sonchus* sp.), carolina geranium (*Geranium carolinianum* L.), cressleaf groundsel (*Senecio glabellus* Poir.), goldenrod (*Solidago* sp.), rescuegrass (*Bromus catharticus* Vahl.), carolina foxtail (*Alopecurus carolinianus* Walt.), wild celery (*Apium* sp.), old field toadflax (*Linaria canadensis* (L.) Dumont), little barley (*Hordeum pusillum* Nutt), common chickweed (*Stellaria media* (L.) Vill.), and johnsongrass.

Table 4. Foliar cover of various weed species on May 20, 1983, following two consecutive years of spring only or spring + layby herbicide treatments near Rougon, Louisiana.

Herbicide and rate				Weed species[4]									
Spring		Layby		GERCA	SENGL	BROCA	ALOCA	APUSS	LINCA	HORPU	STEME	SORHA	Total
(kg/ha)		(kg/ha)		Foliar cover (%)									
Untreated	---	---	---	3 a[1]	0 a	20 a	5 a	5 a	20 a	14 a	6 a	8 a	87 a
Fenac	3.0	---	---	5 a	8 a	0 c	4 a	11 a	18 a	5 a	6 a	15 a	81 a
Fenac	1.7	Fenac[3]	1.7	1 a	2 a	0 c	15 a	15 a	8 a	0 a	2 a	13 a	57 a
Terbacil	1.7	---	---	1 a	10 a	3 bc	1 a	2 a	6 a	14 a	1 a	0 a	40 b
Terbacil	1.1	Terbacil[3]	1.1	0 a	0 a	9 b	1 a	0 a	13 a	15 a	0 a	1 a	39 b
Metribuzin	2.7	---	---	10 a	10 a	0 c	2 a	14 a	13 a	5 a	12 a	2 a	68 a
Metribuzin	1.7	Metribuzin[3]	1.7	0 a	0 a	0 c	0 a	0 a	0 a	0 a	0 a	0 a	1 c
Metribuzin	2.2	Ametryn[2]	2.2	0 a	0 a	0 c	0 a	0 a	0 a	0 a	0 a	0 a	0 c
Metribuzin	2.2	Paraquat[3]	0.6	0 a	0 a	0 c	0 a	0 a	0 a	0 a	0 a	0 a	0 c
Metribuzin	2.2	Asulam[3]	3.7	0 a	0 a	0 c	0 a	0 a	0 a	0 a	0 a	0 a	0 c

1/Means within the same column followed by the same letter are not significantly different according to Duncan's New Multiple Range Test at the 95% level of confidence.

2/Plus 1% v/v Atplus 411F.

3/Plus 0.5% X-77.

4/SONSS: Sowthistle; GERCA: Carolina geranium; SENGL: Cressleaf groundsel; SOOSS: Goldenrod; BROCA: Rescuegrass; ALOCA: Carolina foxtail; APUSS: Wild celery; LINCA: Oldfield toadflax; HORPU: Little barley; STEME: Common chickweed; SORHA: Johnsongrass.

Fenac was weak on almost all species on the study area with the exception of rescuegrass. A spring application of metribuzin at 2.7 kg/ha did not provide adequate weed control. As in the Paincourtville location, the addition of fenac as a layby treatment did not improve weed control compared to fenac applied in the spring only. Both resulted in poor weed control by second stubble. The addition of a layby application of terbacil did not improve weed control compared to terbacil applied in the spring. However, both treatments provided weed control levels that were superior to fenac. A split application of metribuzin at spring and layby improved weed control levels above metribuzin applied alone at 2.7 kg/ha in the spring. As in Paincourtville, metribuzin applied in the spring at 2.2 kg/ha followed by a layby application of ametryn at 2.2 kg/ha, paraquat at 0.6 kg/ha or asulam at 3.7 kg/ha provided excellent weed control.

It is difficult to explain why nonresidual herbicides such as paraquat and asulam would continue to provide control of winter weeds as indicated by this study. The same phenomenon was also observed at the Paincourtville site. No differences in soil disturbance or litter accumulation were observed on plots. Also, layby treatments did not decrease the seed production of winter annuals in that applications were made well after maturity of these plants. No differences in sugarcane populations were observed; thus, improved competitive ability of the crop does not explain the improved weed control.

Although weed control data clearly supports the use of layby applications in sugarcane, actual yield of sugarcane was not affected as dramatically during the three-year cycle (Tables 5 and 6). Because of the implication that layby treatments may actually be injurious to sugarcane, yields are categorized into major components, and means are listed according to individual herbicide treatments.

Table 5. Second stubble sugarcane stalk population, mean stalk weight, sucrose content, and calculated sugar yield following various weed control practices during a 3-year cropping cycle from 1981 to 1983 near Paincourtville and Rougon, Louisiana.

Spring		Layby		Stalk	Mean stalk	Sucrose	Calculated sugar
Chemical	Rate	Chemical	Rate	population	weight	content	yield
	(kg/ha)		(kg/ha)	(stalks/ha x 1000)	(kg)	(%)	(kg/ha)
Untreated	---	---	---	45 c[1]	0.85 a	18.1 a	4010 a
Fenac	3.0	---	---	60 b	0.97 a	18.3 a	5370 ab
Fenac	1.7	Fenac[3]	1.7	66 ab	0.81 a	17.4 a	5770 b
Terbacil	1.7	---	---	67 ab	0.85 a	18.0 a	5850 b
Terbacil	1.1	Terbacil[3]	1.1	68 ab	0.79 a	18.3 a	5620 b
Metribuzin	2.7	---	---	74 a	0.84 a	18.6 a	6690 b
Metribuzin	1.7	Metribuzin[3]	1.7	74 a	0.74 a	16.4 a	5760 b
Metribuzin	2.2	Ametryn[2]	2.2	71 ab	0.85 a	17.8 a	6280 b
Metribuzin	2.2	Paraquat[3]	0.6	74 a	0.76 a	18.0 a	5940 b
Metribuzin	2.2	Asulam[3]	3.7	74 a	0.85 a	18.3 a	6590 b

[1]Means within a column followed by the same letter are not significantly different according to Duncan's New Multiple Range Test at the 95% level of confidence. Means were averaged across locations.

[2]Applied with 1.0% v/v Atplus 411F.

[3]Applied with 0.5 v/v X-77.

Major differences in sugarcane stalk population between treatments were not apparent until the second stubble crop (Table 5). In the plant cane and first stubble crops, untreated areas had sugarcane stalk populations comparable to that of most other treatments. By second stubble, stalk populations on nontreated plots were 30 to 40% less than that of treated plots. When means were grouped according to treatment categories, i.e. untreated, spring application only, and spring plus layby application, differences were also not detected until the second stubble crop (Table 6). At that time the spring only and spring plus layby treatments were significantly higher than that of the untreated plots. Layby treatments did not increase stalk populations compared to that of the spring treatment alone.

Mean stalk weight of sugarcane was unaffected by herbicide treatments throughout the complete sugarcane cycle (Table 5), indicating that weed competition was not sufficiently severe to affect sugarcane stalk growth. When means were determined

across general treatments, no differences were detected until the second stubble crop where mean stalk weights for the spring only and untreated plots were equal and higher than that of layby treatments (Table 6). This decrease in mean stalk weight by layby treatments may indicate that some injury occurred. Sucrose content of sugarcane was unaffected by herbicide treatments (Table 5) and when means were determined across treatment categories, differences were not detected (Table 6).

Table 6. Yield components of sugarcane estimated across all individual treatments and categorized as untreated, spring herbicide application only, and spring plus layby herbicide application.

Application time	Plant cane	First stubble[1]	Second stubble
Stalk population (plants/ha x 1000)			
Untreated	71 a[2]	78 a	45 a
Spring only	69 a	83 a	67 b
Spring and layby	71 a	85 a	71 b
Mean stalk weight (kg)			
Untreated	1.19 a	0.76 a	0.85 ab
Spring only	1.23 a	0.82 a	0.89 b
Spring and layby	1.23 a	0.84 a	0.80 a
Sucrose (%)			
Untreated	16.1 a	---[3]	18.1 a
Spring only	16.2 a	---	18.3 a
Spring and layby	16.3 a	---	17.7 a
Sugar production (kg/ha)			
Untreated	7360 a	---	4010 a
Spring only	7610 a	---	5970 b
Spring and layby	7720 a	---	5990 b

[1]Paincourtville location only.

[2]Means within a column and yield component followed by the same letter are not significantly different according to *a priori* contrasts at the 95% level of confidence.

[3]No data.

The most important test for differences in weed control is the effect on sugar yield of sugarcane on the test sites. In plant cane, no individual treatment resulted in improved commercial sugar yield over that of the untreated plot (Table 5). In the second stubble crop, all treatments with the exception of a spring only application of fenac resulted in commercial sugar yields higher that that of the untreated plot. When means were expressed across treatment categories for second stubble, sugar yield for spring only and spring plus layby treatments was equal and significantly higher than the untreated control (Table 6).

In this study, layby application of herbicides resulted in weed control superior to that of a spring only herbicide application. Thus, use of a layby treatment shows potential for removing weed competition as a factor in the low yields associated with cane, and possibly increasing the number of stubble years.

Since layby application of herbicides did not improve yields of sugarcane, such treatments should not be recommended for similar weed infestations unless specific weed problems that cause harvest difficulties are present. On a long term basis, layby herbicide applications could decrease the soil seedbank populations, resulting in decreased need for herbicides in future years. Also, layby applications may be warranted where heavy infestations of tall growing grasses are present. Layby applications may also be excellent tools for maintaining sugarcane stands for seed cane free of weeds and weed seed. Postemergence directed applications of ametryn, atrazine, asulam, or metribuzin at layby would maintain these sugarcane stands virtually weed-free. These results further substantiate previously drawn conclusions (2,4,5,6,9,7) which indicated that layby application of herbicides in various crops improved weed control, but did not necessarily improve yields except in heavy weed infestations.

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ESTIMATING THE ECONOMIC IMPACT OF SUBSURFACE DRAINAGE ON SUGARCANE PRODUCTION IN LOUISIANA

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ABSTRACT

Physical input-output data from on-the-farm experiments conducted by Carter and others on two soil types provided yield differentials and operating cost information for various subsurface drainage system configurations. These data were used to appraise the economic feasibility of various combinations of system configurations and cost options for owner and tenant operators on two soil types. Net present values were computed for 18 situations. The results indicate economic returns over the estimated 15-year life of the system measured as net present value, ranged from \$603.08 per acre for the most favorable situation to -\$296.31 per acre for the least favorable situation. In all cases owner situations are more favorable. It appears that the interrelationship between soil type and the immediate water table is a major determinant of output. Modification of this soil-water relationship with a subsurface drainage system almost always resulted in an increase in output. However, the economic analysis showed that the profitability potential is more constrained.

INTRODUCTION

The positive interaction between sugarcane yields and proper field drainage in Louisiana is well documented (7). A properly designed drainage system has two primary functions. First, it provides an outlet for excess quantities of subsurface water on moderately and poorly drained soils that normally results in long term saturation and water logging conditions. Second, it permits excess quantities of surface water to be removed in an effective yet soil conserving manner (1).

Louisiana sugarcane growers have historically combined a system of quarter drains, cross and lateral ditches, and adequately sized outlets to facilitate surface and subsurface drainage (8). These drainage systems have, in most cases, effectively handled surface and subsurface water problems on farms. However, their design substantially reduces that portion of the farm in cropland, increases the incidence of unwanted broad leaf weeds and grasses, and limits the effective use of modern machinery. These shortcomings reduce potential farm income, the former by reducing total attainable output and the latter two by increasing per acre costs.

Carter, Camp, and McDaniel developed, tested, and evaluated, under farm conditions, an alternative drainage system that addresses the above defined shortcomings. The system utilizes precision laid subsurface 10-centimeter diameter, perforated, corrugated, polyethylene drains, tied into a 20-centimeter diameter main drain, terminating at a metal sump with an automatic electric pump to lift water from the sump to a drainage outlet (4).

MATERIALS AND METHODS

Carter, Camp, and McDaniel conducted on-farm experiments at one site nine years and four years at another site to identify yield differentials between subsurface and current drainage systems. The tests provide yield data for different spacings of subsurface drains and a standard surface drainage configuration on two soil types (2, 3). These results, presented in Tables 1 and 2, indicate that subsurface drainage systems will in most years increase output per acre measured in either tons of cane or pounds of raw sugar. Standard statistical tests of significance were not attainable as these are preliminary data obtained from the first and second cycles of long term (15 year) field tests.

Table 1. Sugarcane yield data, subsurface drainage experiments, Jeanerette silty clay loam, South Louisiana.

Year	Crop	Spacing Feet 45	90	135	Check	Spacing Feet 45	90	135	Check
		Cane(Tons/Acre)				Sugar (Pounds/Acre)			
1979	fal.	0	0	0	0	0	0	0	0
1980	plc.	35.8	34.8	29.2	33.6	5261	5281	5063	4612
1981	1stb.	40.1	41.3	34.8	30.8	7114	7119	6703	5360
1982	2stb.	29.6	28.2	24.6	19.2	4820	4979	3519	2782

Table 2. Sugarcane yield data for subsurface drainage experiments, Commerce silt loam, South Louisiana.

Year	Crop	Spacing Feet 80	120	160	Check	Spacing Feet 80	120	160	Check
		Cane(Tons/Acre)				Sugar (Pounds/Acre)			
1976	fal.	.00	.00	.00	.00	0	0	0	0
1977	plc.	33.90	33.85	34.73	30.80	5739	5181	5971	5088
1978	1stb.	40.40	41.35	41.77	45.70	6639	5280	6619	7664
1979	2stb.	40.85	40.90	40.87	35.10	7534	7894	7536	5918
1980	3stb.	31.31	31.20	32.60	28.19	4973	4571	4791	4500
1981	fal.	.00	.00	.00	.00	0	0	0	0
1982	plc.	42.75	42.93	40.30	43.65	8458	7872	7176	7563
1983	1stb.	31.68	35.89	32.39	29.07	7146	7862	7012	6610
1984	2stb.	33.60	32.70	33.32	26.78	6121	4944	5260	4875

An economic appraisal of alternative production practices utilized the value of the output differential and the cost differential between experimental and current practices. Yield differentials in pounds of raw sugar per acre are directly attainable from Tables 1 and 2. The expected productive life of the subsurface system is 15 years. Thus, yield differential data for the 9-year test on a Commerce silt loam were expanded using the average of results for plant cane and ratoon crops. Similar adjustments were made for the 4-year test on a Jeanerette silty clay loam. The yield data used in the economic analysis are shown in Table 3.

Table 3. Sugar yield data, actual and projected, subsurface drainage and check, Jeanerette silty clay loam and Commerce silt loam, South Louisiana.

Year	Jeanerette silty clay loam: 90 foot spacing	Check	Difference	Commerce silt loam: 160 foot spacing	Check	Difference
	Raw Sugar (Pounds/Acre)					
0	0	0	0	0	0	0
1	5281	4612	669	5971	5088	883
2	7119	5360	1759	6619	7664	-1045
3	4979	2782	2197	7536	5918	1618
4	0	0	0	4791	4500	291
5	5281(P)[1/]	4612(P)	669(P)	0	0	0
6	7119(P)	5360(P)	1759(P)	7176	7563	-387
7	4979(P)	2782(P)	2197(P)	7012	6610	402
8	0(P)	0(P)	0(P)	5260	4875	385
9	5281(P)	4612(P)	669(P)	4791(P)	4500(P)	291(P)
10	7119(P)	5360(P)	1759(P)	0(P)	0(P)	0(P)
11	4979(P)	2782(P)	2197(P)	6573(P)	6325(P)	248(P)
12	0(P)	0(P)	0(P)	6815(P)	7137(P)	-322(P)
13	5281(P)	4612(P)	699(P)	6398(P)	5396(P)	1002(P)
14	7119(P)	5360(P)	1759(P)	4791(P)	4500(P)	291(P)
15	4979(P)	2782(P)	2197(P)	0(P)	0(P)	0(P)

1/Projected.

Initial capital costs per acre for the various subsurface drainage system configurations are shown in Table 4.

Table 4. Initial capital investment per acre for all experimental subsurface drainage system configurations, South Louisiana, 1985.

Lateral Pipe Cost/ft	Spacing in feet					
	45	80	90	120	135	160
			dollars			
$ .50	572.00	360.25	330.00	270.00	249.34	224.13
.60	668.00	414.70	378.40	306.00	281.60	251.35
.75	814.00	496.38	451.00	361.00	330.00	292.19

Per acre capital expenditures for main piping, pumps and sumps are constant, while the capital expenditures per acre for drains is dependent on the spacing employed. Pumps are replaced every 5 years. Prices for capital items reflect current market values. Annual repairs and operating expenses used in the analysis were collected at the test sites. Output was measured in pounds of raw sugar and gallons of molasses per acre and priced at 21.5 and 25.0 cents respectively and adjusted to reflect the usual division between the raw sugar factory, landlord, and grower. Harvesting rebates and expenses associated with the output differential were based on reports previously published by Chapman et al., and Heagler et al. (5,6).

RESULTS AND DISCUSSION

Farmers usually choose to modify current production practices whenever a cash expenditure results in an immediate increase in output and net returns in the same production period. However, cash investment decisions that incur costs in one production period and generate income in future production periods are more difficult to address. These decisions require a "time" analysis to provide a meaningful comparison between and among cash expenditure and cash investment alternatives. This can be done by determining the "net current value" of the additional income generated from cash investment alternatives and comparing these "current dollar" measures to ascertain the economic viability among these options as well as returns generated by cash expenditure alternatives.

All combinations of drain spacing for two soils, two tenure situations and three different rates for the purchase and installation of polyethylene piping were included in the initial economic analysis. These results are summarized in Table 5. The analysis utilizes net present value technique to estimate costs and returns in current dollars over a 15-year period. A 13 percent discount rate was used to account for a normal rate of return on the current dollars invested.

Table 5. Summary of per acre net present values for subsurface drainage systems by soil type, drain spacing, tenure situation and piping price/foot, Louisiana, 1985.

Pipe Price per foot[1/]	Jeanerette silty clay loam						Commerce silt loam					
	Spacing in feet											
	45		90		135		80		120		160	
	Owner	Tenant	Owner	Tenant	Owner	Tenant	Owner	Tenant	Owner	Tenant	Owner	Tenant
$ .50	294.34	95.36	603.08	396.29	261.38	145.32	-63.88	-139.82	-158.67	-196.03	-63.19	-109.55
$ .60	187.12	-11.86	549.46	342.68	225.64	109.57	-124.05	-199.99	-198.78	-236.14	-93.27	-139.64
$ .75	26.28	-172.70	469.04	230.00	172.02	55.96	-158.67	-290-24	-258.95	-296.31	-138.40	-184.77

1/ Installation and materials.

These results indicate that the relationship between soil type and subsurface drainage configuration is extremely important. Further, one cannot assume that experimental results on one soil type can be used as a basis of inference to another soil type. The per acre net present values underlined are the most economically favorable situations identified for more detailed study.

An in-depth real and discounted cash flow and a break-even analysis of the most favorable situation for both owner and tenant operations given each soil situation are presented in Tables 6, 7, 8 and 9. A pipe installation and materials price of $ .60 per foot was used to reflect current costs. For the Jeanerette silty clay loam soil situation, the 90-foot drain spacing was found to be the best economic alternative. However, the 160-foot spacing was the least worse economic alternative for the Commerce silt loam situation.

Table 6. Summary of actual cash flow and discounted cash flow for one acre of subsurface drained sugarcane, lateral piping at $ .60 per foot, 90-foot spacing, owner-operator, Jeanerette silty clay loam, South Louisiana.

Year	Added cost	Added returns	Pv. of added cost	Pv. of added returns	Annual net cash returns	Residual value of equipment	Net present value	Net pres. value equipment	NPV at termen. no comp.	NPV at termen. comp.	Return on $ invested
	1	2	3	4	5	6	7(4-3)	8	9	10(8+9)	11
Total			527.53	1076.99			549.46				1.04
0	378.40	.00	378.40	.00	-378.40	378.40	-378.40	378.40	-378.40	.00	
1	11.71	90.71	10.36	80.28	79.00	350.24	69.91	309.95	-308.49	1.46	
2	30.87	247.69	24.18	193.98	216.82	322.08	169.80	252.24	-138.69	113.55	
3	27.78	304.22	19.25	210.84	276.44	293.92	191.51	203.70	52.90	256.60	
4	9.24	.00	5.67	.00	-9.24	265.76	-5.67	163.00	47.23	210.23	
5	33.71	90.71	18.30	49.23	57.00	259.60	30.94	140.90	78.17	219.07	
6	30.87	247.69	14.83	118.97	216.82	231.44	104.14	111.16	182.31	293.47	
7	27.78	304.22	11.81	129.31	276.44	203.28	117.50	86.41	299.81	386.22	
8	9.24	.00	3.48	.00	-9.24	175.12	-3.48	65.87	296.34	362.21	
9	11.71	90.71	3.90	30.20	79.00	146.96	26.30	48.92	322.63	371.56	
10	52.87	247.69	15.57	72.97	194.82	140.80	57.39	41.48	380.03	421.50	
11	27.78	304.22	7.24	79.31	276.44	112.64	72.07	29.36	452.09	481.46	
12	9.24	.00	2.13	.00	-9.24	84.48	-2.13	19.49	449.96	469.45	
13	11.71	90.71	2.39	18.52	79.00	56.32	16.13	11.50	446.09	477.59	
14	30.87	247.69	5.58	44.75	216.82	28.16	39.17	5.09	505.26	510.35	
15	27.78	304.22	4.44	48.64	276.44	.00	44.20	.00	549.46	549.46	

Table 7. Summary of actual cash flow and discounted cash flow for one acre of subsurface drained sugarcane, lateral piping at $ .60 per foot, 90-foot spacing, tenant-operator, Jeanerette silty clay loam, South Louisiana.

Year	Added cost	Added returns	Pv. of added cost	Pv. of added returns	Annual net cash returns	Residual value of equipment	Net present value	Net pres. value equipment	NPV at termen. no comp.	NPV at termen comp.	Return on $ invested
	1	2	3	4	5	6	7(4-3)	8	9	10(8+9)	11
Total			527.53	870.21			342.68*				.65
0	378.40	.00	378.40	.00	-378.40	378.40	-378.40	378.40	-378.40	.00	
1	11.71	72.87	10.36	64.49	61.16	350.24	54.12	309.95	-324.28	-14.33	
2	30.87	200.78	24.18	157.24	169.91	322.08	133.06	252.24	-191.22	61.02	
3	27.78	245.63	19.25	170.23	217.85	293.92	150.98	203.70	-40.24	163.46	
4	9.24	.00	5.67	.00	-9.24	265.76	-5.67	163.00	-45.91	117.09	
5	33.71	72.87	18.30	39.55	39.16	259.60	21.25	140.90	-24.65	116.25	
6	30.87	200.78	14.83	96.44	169.91	231.44	81.61	111.16	56.95	168.12	
7	27.78	245.63	11.81	104.41	217.85	203.28	92.60	86.41	149.55	235.96	
8	9.24	.00	3.48	.00	-9.24	175.12	-3.48	65.87	146.08	211.95	
9	11.71	72.87	3.90	24.26	61.16	146.96	20.36	48.92	166.43	215.36	
10	52.87	200.78	15.57	59.15	147.91	140.80	43.57	41.48	210.01*	251.48	
11	27.78	245.63	7.24	64.03	217.85	112.64	56.79	29.36**	266.80	296.16	
12	9.24	.00	2.13	.00	-9.24	84.48	-2.13	19.49	264.67	284.16	
13	11.71	72.87	2.39	14.88	61.16	56.32	12.49	11.50	277.15	288.65	
14	30.87	200.78	5.58	36.28	169.91	28.16	30.70	5.09	307.85	312.94	
15	27.78	245.63	4.44	39.27	217.85	.00	34.83	.00	342.68	342.68	

Table 8. Summary of actual cash flow and discounted cash flow for one acre of subsurface drained sugarcane, lateral piping at $ .60 per foot, 160-foot spacing, tenant-operator, Commerce silt loam, South Louisiana.

Year	Added cost	Added returns	Pv. of added cost	Pv. of. added returns	Annual net cash returns	Residual value of equipment	Net present value	Net pres. value equipment	NPV at termen. no comp.	NPV at termen comp.	Return on $ invested
	1	2	3	4	5	6	7(4-3)	8	9	10	11
Total			341.21	201.57			-139.64				-.41
0	251.35	.00	251.35	.00	-251.35	251.35	-251.35	251.35	-251.35	.00	
1	15.22	99.12	13.47	87.71	83.89	231.66	74.24	205.01	-177.11	27.90	
2	-.98	-116.44	-.77	-91.18	-115.45	211.97	-90.42	166.00	-267.53	-101.52	
3	19.00	179.85	13.17	124.65	160.85	192.28	111.48	133.26	-156.05	-22.79	
4	16.20	36.63	9.94	22.46	20.42	172.59	12.52	105.85	-143.53	-37.67	
5	29.12	.00	15.81	.00	-29.12	174.90	-15.81	94.93	-159.33	-64.40	
6	.22	-45.44	.11	-21.82	-45.66	155.21	-21.93	74.55	-181.26	-106.71	
7	13.95	47.07	5.93	20.01	33.11	135.52	14.07	57.60	-167.19	-109.58	
8	20.59	49.32	7.75	18.55	28.72	115.83	10.80	43.57	-156.38	-112.81	
9	16.20	36.63	5.40	12.19	20.42	96.14	6.80	32.00	-149.59	-117.58	
10	29.12	.00	8.58	.00	-29.12	98.45	-8.53	29.00	-158.17	-129.16	
11	7.72	26.83	2.01	7.00	19.12	78.76	4.98	20.53	-153.18	-132.65	
12	6.48	-34.69	1.50	-8.00	-41.17	59.07	-9.50	13.63	-162.68	-149.05	
13	19.80	114.59	4.04	23.39	94.79	39.38	19.35	8.04	-143.33	-135.29	
14	16.20	36.63	2.93	6.62	20.42	19.69	3.69	3.56	-139.64	-136.08	
15	.00	.00	.00	.00	.00	.00	.00	.00	-139.64	-139.64	

Table 9. Summary of actual cash flow and discounted cash flow for one acre of subsurface drained sugarcane, lateral piping at $ .60 per foot, 160-foot spacing, owner-operator, Commerce silt loam, South Louisiana.

Year	Added cost	Added returns	Pv. of added cost	Pv. of. added returns	Annual net cash returns	Residual value of equipment	Net present value	Net pres. value equipment	NPV at termen. no comp.	NPV at termen comp.	Return on $ invested
	1	2	3	4	5	6	7(4-3)	8	9	10	11
Total			341.21	247.94			-93.27				-.27
0	251.35	.00	251.35	.00	-251.35	251.35	-251.35	251.35	-251.35	.00	
1	15.22	122.67	13.47	108.55	107.44	231.66	95.08	205.01	-156.27	48.74	
2	-.98	-144.32	-.77	-113.02	-143.33	211.97	-112.25	166.00	-268.52	-102.52	
3	19.00	223.02	13.07	154.56	204.01	192.28	141.39	133.26	-127.13	6.13	
4	16.20	44.41	9.94	27.24	28.20	172.59	17.30	105.85	-109.84	-3.98	
5	29.12	.00	15.81	.00	-29.12	174.90	-15.81	94.93	-125.64	-30.71	
6	.22	-55.75	.11	-26.78	-55.97	155.21	-26.88	74.55	-152.53	-77.98	
7	13.95	57.80	5.93	24.57	43.84	135.52	18.64	57.60	-133.89	-76.29	
8	20.59	59.31	7.75	22.42	39.01	115.83	14.67	43.57	-119.22	-75.65	
9	16.20	44.41	5.40	14.78	28.20	96.14	9.39	32.00	-109.83	-77.83	
10	29.12	.00	8.58	.00	-29.12	98.45	-8.58	29.00	-118.41	-89.41	
11	7.72	33.45	2.01	8.72	25.73	78.76	6.71	20.53	-111.70	-91.17	
12	6.48	-43.26	1.50	-9.98	-49.74	59.07	-11.48	13.63	-123.18	-109.55	
13	19.80	141.31	4.04	28.85	121.51	39.38	24.81	8.04	-98.37	-90.33	
14	16.20	44.41	2.93	8.02	28.20	19.69	5.10	3.56	-93.27	-89.72	
15	.00	.00	.00	.00	.00	.00	.00	.00	-93.27	-93.27	

The economic analysis indicates that growers with a Jeanerette silty clay loam soil resource can expect favorable rates of return from an investment in a subsurface drainage system. Economic indicators are more favorable for owners than tenants, the per acre net present value is $206.78 higher for owners (Column 7, Tables 6 and 7; $549.46 - $342.68), the net returns per dollar invested (in current dollars) is $ .39 higher for owners (Column 11, Tables 6 and 7; $1.04 - $ .65), and the pay out period is considerable shorter - 4 years for owners and 7 years for tenants (Column 9, Tables 6 and 7).

The analysis provides a basis to evaluate the adverse economic impact associated with loss of the use of land once such an investment is made. This is particularly important to tenant growers. The rental contract must cover at least 7 years for a tenant grower to recover his initial capital and annual costs. Termination of the rental arrangement after the 7th year forces the tenant to forego expected income.

This lost income is a combination of residual value in the investment in the system and lost income. For example, if a tenant's lease were terminated after year 10, he would forego $132.67 in returns per acre ($342.68* - $210.01*) (Table 7, Columns 7 and 9); 29.36** for the loss of value remaining in the capital investment, and $103.31 ($132.67 - $29.36) in lost income earnings. Tenant interest in such an investment will be minimal until lease lengths and terms are modified so that an orderly and equitable disposition of any residual values can be affected if a lease is terminated.

Economic evaluation of the Commerce silt loam test indicates a subsurface drainage system is not financially feasible. A third stubble crop was obtained from all subsurface drain configurations as well as the check, however, the negative yield differentials associated with all subsurface configurations in 1978 and with the 160-foot spacing in 1982 have considerable impact on potential financial feasibility. Economic indicators were all negative, but were better for owners than for tenants (Tables 8 and 9). Per acre net present value (Table 9, Column 9) ranged from -$93.27 to -$139.64; net returns per dollar invested were $ .14 higher for owners but still negative (-$.27); and the system will not pay out at any point during its 15-year life.

CONCLUSION

This analysis indicates the interrelationship between soil type and surface/subsurface drainage configurations in conjunction with current agronomic and mechanical technology does affect production and income. However, the yield enhancement potential of subsurface drainage systems will not necessarily justify their installation on all soil situations. Such an expenditure on well drained soils would be ill advised. On the other hand, there appears to be considerable opportunity to improve net income with such an expenditure on those soil types with less favorable structural and water holding characteristics than Commerce silt loams and more favorable structural and water holding characteristics than Sharkey clays. It is possible that the negative yield responses associated with Commerce silt loam soils were anomalies and, if so proven, their adjustment could alter the financial outcome presented in this analysis. No effort was made to address the potential cost savings accruing to subsurface drainage systems from more efficient use of machinery and reduced weed control outlays, nor the additional income from field redesign that would increase the percent of land in cropland. The current subsurface drainage experiments should be continued and expanded to address these questions.

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SUGARCANE PRODUCTION IN THE EVERGLADES FOLLOWING RICE

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ABSTRACT

Everglades sugarcane growers can produce rice during the summer on land fallowed between sugarcane crops. A study was conducted on organic soil in the central Everglades Agricultural Area to determine whether rice culture affects sugarcane production in the plant crop following rice. Sugarcane production from commercial fields in which rice was produced during the summer prior to sugarcane (termed rice fields) was compared with that from nearby fields in which there was no rice production (termed check fields). Comparable fields were planted with the same sugarcane varieties, generally within two-week periods, and were harvested within the same time span. Summer fallowed fields were not flooded, whereas those used for rice were flooded as part of the normal rice culture.

Gross cane yield in fields following rice was 46.5 tons/acre, compared to 42.7 tons/acre in fields not cropped to rice. Important differences were observed in juice quality. Fields following rice averaged 81.4% purity, compared to 77.2% in check fields. Sucrose and net standard tons averaged 14.4 vs 12.6%, and 52.9 vs 41.4 tons/acre, in rice and check fields, respectively. Recoverable sugar per acre (RSPA) was 4.8 and 3.8 tons in rice and check fields, respectively. Using a sugarcane price of $23.85/net standard ton, fields following rice produced $234.27/acre more income than summer fallowed fields, after accounting for harvesting costs.

An examination of the data indicated that RSPA was increased by K fertilization. Since rice fields in general received more K fertilization prior to sugarcane planting than did check fields, part of the rice effect may be attributable to K fertilization. But statistical analysis indicated that differences in K fertilization accounted for only a portion of the rice effect. For example, at a K_2O fertilization rate of 180 lbs/acre on both rice and check fields, RSPA averaged 0.67 tons/acre higher in the rice fields.

INTRODUCTION

The Everglades Agricultural Area (EAA) is located in the northern part of the Everglades, immediately south of Lake Okeechobee. Organic soils (Histosols), generally containing 85% or more organic matter, comprise most of the EAA. Sugarcane (*Saccharum* spp.) is the major crop in the Everglades. A common cultural system involves a plant crop that is established during the fall and harvested approximately one year later, followed by two or three ratoon crops harvested at yearly intervals. At the conclusion of this cycle, the land may be summer fallowed until another plant crop is established in the fall. Fallow fields may be flooded for a few weeks for insect, disease, and/or nematode control.

During the summer fallow period, Everglades sugarcane growers have sufficient time to produce rice (*Oryza sativa* L.). Rice production during this period can increase farm income without seriously interfering with normal sugarcane production practices (3). Rice generally is seeded on prepared land with a grain drill. After seedlings are tall enough to withstand a 4- to 6-inch flood (generally 3 to 6 weeks after seeding), the land is flooded until a few weeks before harvest. The total flooded period is approximately 10 weeks. Following harvest, the fields may be re-flooded for about 8 weeks for production of a ratoon crop of rice.

Since sugarcane is the principle crop in the sugarcane-rice rotation, it is important to know what effect the optional rice culture has on sugarcane production. In the only study of its type (2), it was concluded that plant crop sugarcane in fields that were cropped to rice prior to planting produced higher cane tonnage, higher sucrose, more sugar per acre, and greater net income than sugarcane grown in summer fallowed fields. The study used a multiple linear regression analysis of data obtained from producers' records. The statistical technique was used to account for various sources of variation in the data set (years, farms, varieties) so that the effect of rice production, as opposed to summer fallow without flooding,

on sugarcane production could be examined. The data set contained few instances in which presence or absence of rice prior to sugarcane planting was the only production factor that varied between two observations.

The present study was undertaken to provide a direct comparison of plant crop sugarcane production in fields with and without rice production prior to sugarcane planting, with factors such as sugarcane variety, planting and harvesting dates, location and farm management being similar for paired fields.

METHODS AND MATERIAL

Rice was grown during the 1983 season in three locations on the Big B Farm property in the central EAA, on a Terra Ceia muck soil (euic, hyperthemic typic Medisaprist). Rice was produced in three fields at Location 1, in four fields at Location 2, and in eight fields at Location 3. An equal number of fields in which there was no rice production was selected in Locations 1 and 3 on the basis of having been planted with the same varieties of sugarcane on approximately the same dates as were used in the rice fields. At Location 2, five fields were selected for comparison with the rice fields. The fields lacking rice production (termed "check" fields) were not flooded during the summer, whereas the "rice" fields were flooded a total of approximately 150 days during the plant and ratoon rice crops as part of the normal production system. Most fields were approximately 35 acres in size, except the check fields at Location 3 averaged 23 acres.

Prior to sugarcane planting in the late fall and early winter of 1983-1984, all fields were fertilized in approximate accordance with the Everglades Agricultural Research and Education Center Soil Test Laboratory recommendations (6). Sugarcane variety CP 72-1210 was planted at Location 1 between November 25, 1983, and January 7, 1984. Variety CP 70-1133 was planted at Locations 2 and 3 between November 8, and November 20, 1983. Standard commercial sugarcane production practices were used throughout the growing season.

The sugarcane was burned and hand harvested. Harvest dates were December 11-25, 1984, January 31 to February 14, 1985, and January 13 to February 8, 1985, for Locations 1, 2, and 3, respectively. Data for gross tons, Brix (percentage of soluble solids in undiluted sugarcane juice), purity (apparent purity of the soluble solids, % polarization, i.e., percent of the solids that is sugar), sucrose (percentage of sucrose in sugarcane juice), 96° yield (percentage of raw sugar in sugarcane, for sugar that is 96% pure), and recoverable sugar per acre (RSPA) were provided by the Sugar Cane Growers Cooperative of Florida, Glades Sugar House, for each field. Tonnage, expressed as standard tons, was calculated by multiplying gross tons by a juice quality factor (F) that is related to percent sucrose (S) as $F = -0.248909 + 0.0999583 \cdot S$ (1). Net standard tons were calculated by subtracting from standard tons a 4% allowance for trash in hand harvested cane.

The data were analyzed as a factorial design, with sources of variation being location, field type (rice or no rice prior to sugarcane), and interaction between these factors. The Statistical Analysis System (SAS) GLM and RSQUARE techniques were used to further examine the data (8).

RESULTS AND DISCUSSION

Cropping with rice prior to planting substantially increased all measurements of production in the sugarcane plant crop at all locations, except for gross tons of cane at Location 3 (Table 1). There were significant Location by field type interactions for some of the yield components, but with the exception of gross tons, the interactions appeared to result from varying magnitude of response at different locations rather than from presence or absence or direction of the response. Although averages for quality factors (Brix, purity, sucrose, and 96° yield) at Location 1 were numerically greater in rice, as compared to check fields, there was no significant difference between the two field types at this location. Standard tons and RSPA were significantly greater in rice fields at all three locations.

The average increase in gross tons was only 8.9%, whereas the average increase in standard tons (gross tonnage adjusted for sugar content of the cane) was 27.8%. This difference occurred because, on the average, rice culture prior to sugarcane increased Brix by 8.0% and purity by 5.6%, which resulted in an increase in sucrose of 14.3%. RSPA averaged 1.0 ton per acre greater in the rice fields. Quality factors such as purity and Brix were particularly increased by the rice culture at Locations 2 and 3. Sugarcane at these latter locations was harvested after severe freezes on January 6 and 22, 1985.

TABLE 1. Effect of location and field type on various sugarcane production factors.

Location	Field type	Gross tons	Brix	Purity	Sucrose	Standard[3] tons	96° yield	RSPA
		T/A	%	%	%	T/A	%	T/A
1	Check	42.0	17.5	81.7	14.3	49.7	10.4	4.35
		**[1]/[2]	NS	NS	NS	**	NS	**
	Rice	49.4	18.2	82.9	15.2	63.0	10.8	5.50
2	Check	40.5	15.9	75.9	12.1	38.8	8.4	3.41
		**	**	**	**	**	**	**
	Rice	47.9	16.9	79.6	13.4	52.6	9.6	4.61
3	Check	44.4	16.1	76.4	12.3	43.6	8.6	3.83
		NS	**	**	**	**	**	**
	Rice	44.6	17.7	81.9	14.5	53.6	10.5	4.70
Average[4]	Check	42.7	16.3	77.2	12.6	43.2	8.9	3.80
	Rice	46.5	17.6	81.5	14.4	55.2	10.3	4.80
Significance[2]								
Location		NS	**	**	**	**	**	**
Field type		**	**	**	**	**	**	**
Location x field type		*	*	*	*	NS	**	NS

[1] Statistical significance for field type comparisons within a single location.

[2] **,*, and NS represent significance at P<0.01, 0.05, and P>0.05, respectively.

[3] Gross standard tons. To calculate net standard tons decrease by a 4% trash allowance factor.

[4] Averages weighted to reflect the number of fields comprising the average.

A value of $23.85 per net standard ton of cane and a harvesting cost of $10.15 per gross ton were appropriate for the 1984-1985 season. Using these figures, average gross income for the rice and check fields was $1262.55 and $987.15 per acre, respectively. The harvesting costs were $471.03 and $429.90 per acre for rice and check fields, respectively. Thus the increased revenue attributable to rice culture before sugarcane was $234.27 per acre.

The finding that rice culture prior to sugarcane production increased sugar production in the plant crop, relative to summer fallowing, is in agreement with the findings in the study discussed previously (2). For example, in the present study, RSPA was increased 1.0 T/A by rice culture. In the previous study, the increase was 0.93 T/A. It should be emphasized that entirely different data sets were used for these two studies. Thus the present study provides additional evidence of the "rice effect", i.e., increased sugar production in fields formerly cropped to rice.

Neither of the two studies provides any conclusive evidence as to the reason for the rice effect. One common factor between the two studies is that summer fallow fields were not flooded, whereas rice fields were flooded for an extensive period. Flooding is considered to be beneficial to the subsequent crops on organic soils in the Everglades. The question of whether the "rice effect" is due solely to the extensive period of flooding associated with the crop cannot be resolved at this time. However, revenues from rice production should help to offset the expense associated with a long period of flooding. Plant nutrients returned to the soil in the rice straw also may be beneficial to the succeeding crop.

One factor not addressed in the previous study that can be examined in the present study is the difference in pre-plant sugarcane fertilization that was used

in rice and check fields. It is fairly well established that prolonged flooding of the organic soils of the Everglades results in an increase in soil pH, and a decrease in EREC soil test laboratory extractable P and K. The pH increase probably is due in part to the high pH of surface water in the Everglades. However, even using demineralized water in the laboratory, the pH of organic soils has been shown to increase when water saturated (5). Since P is extracted by the soil test lab with water (9), an increase in soil pH can be expected to reduce P solubility (4) and, therefore, extractability. Potassium has been shown to leach during prolonged flooding in the EAA (7). When soil test P and K are lower, recommended rates of P and K are greater. If the soil test recommendations perfectly represented crop needs, and the grower exactly followed the recommendations, then the rice and check fields would have all been equal in fertility prior to sugarcane planting and it would be unnecessary to examine differences in pre-plant fertilization. In fact, however, such an examination seems warranted.

Phosphorus fertilization was used in all former rice fields, but in only two former fallow fields (Table 2). At each location, more K was used in rice fields than in fallow fields. The sugarcane production factor RSPA, which is computed from standard tons, represents a "bottom line" figure to sugarcane producers, since it is directly related to gross income. A plot of RSPA vs K fertilization suggests a positive relationship between these factors, although this conclusion is confounded by the fact that not all K fertilization rates were used at all locations. Thus variation in RSPA may be attributed in part to location differences. The data for rice fields appear to be separate from those for check fields (Figure 1), suggesting that the rice effect was not entirely due to differences in K fertilization. For example, at K_2O fertilization rate of 180 lb/A, RSPA was 0.67 T/A higher in rice than in check fields (Figure 1). The cost for additional pre-plant fertilizer in rice fields was about \$22.00/A, which probably should be subtracted from the value of \$234.27/A presented previously as the increased revenue attributable to rice culture.

Table 2. Soil test values and P and K fertilization in check and rice fields.

Location	Field type	Average soil test results			Average pre-plant fertilization	
		pH	P	K	P_2O_5	K_2O
		lb/A				
1	Check	-	-	-	0	196
	Rice	6.7	5	91	96	243
2	Check	6.0	18	113	0	98
	Rice	6.5	6	97	81	163
3	Check	5.9	8	91	0 or 40[1/]	157
	Rice	6.8	4	74	61	174

1/ Two of the 8 fields at this location received 40 lb/A; 6 received 0 lb/A.

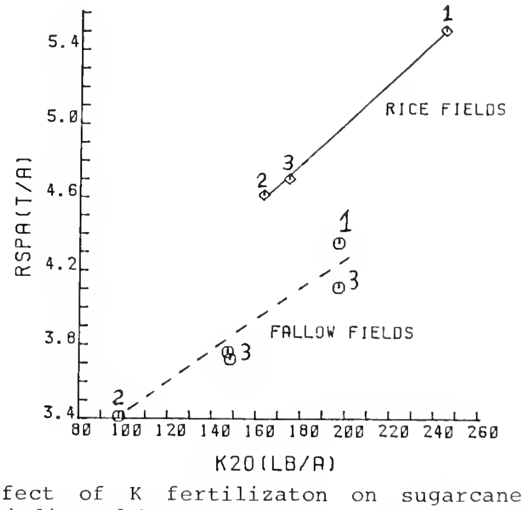

Figure 1. Apparent effect of K fertilizaton on sugarcane RSPA, at Locations 1, 2, and 3 as indicated by the numbers at the data points.

The data are insufficient for determining the effect of P on RSPA. However, it can be noted that for check fields at Location 3 that received nearly the same K_2O fertilization rate, there is no apparent difference in RSPA attributable to P fertilization. Specifically, RSPA in fields fertilized with 40 lb P_2O_5 and 148 lb K_2O/A averaged 3.72 T/A, compared to an average of 3.76 T/A in fields that received no P and 147 lb K_2O/A.

The effect of field type and K on RSPA was investigated using two SAS procedures. The RSQUARE procedure was used to develop the best 1, 2, 3 and 4 factor models to represent the data set (Table 3). The terms field type (rice vs check fields) and K fertilization together accounted for 76% of the variation in the data. Adding the terms location and P fertilization to the model accounted for only 1% additional variation.

Table 3. Best 1, 2, 3, and 4 factor models for RSPA and associated R^2 as determined by the SAS RSQUARE procedure.

Number of Factors	Factors	Model R^2
1	K Fertilization	0.58
2	K Fertilization, field type	0.76
3	K Fertilization, field type, location	0.77
4	K Fertilization, field type, location P fertilization	0.77

The Type I sum of squares information obtained with the GLM procedure was used to examine the influence of the order in which factors were added to the RSPA production model on the statistical significance of the factors (Table 4). Apparently location and K fertilization accounted for somewhat similar sources of variation, since K fertilization was not significant in one of the models that included location as the first entered source of variation, and location was not significant when K fertilization was first entered. But field type was significant regardless of whether or not location and K fertilization were first entered. This indicates that the rice effect cannot be attributed solely to differences in K fertilization used in rice and check fields.

Table 4. Effect of factor order on factor Type I sum of squares for RSPA as determined by SAS GLM procedure.

	First ordering		Second ordering		Third ordering		Fourth ordering	
Order	Factor1/	SS	Factor	SS	Factor	SS	Factor	SS
1	K	**2/	Field	**	Location	**	Location	**
2	Field	**	K	**	Field	**	K	**
3	Location	NS	Location	NS	K	NS	Field	**
4	Location x field	NS	Location x field	NS	Location x field	NS	Location x field	NS
5	P	NS	P	NS	P	NS	P	NS

1/ K=K Fertilization, P=P Fertilization, Field=field type

2/**, *, and NS represent significance at P<0.01, 0.05, and P>0.05, respectively.

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THE USE OF FLUAZIFOP-BUTYL AND SETHOXYDIM AS SUGARCANE RIPENERS

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ABSTRACT

The grass herbicides fluazifop-butyl, (Fusilade 4E) and sethoxydim, (Poast) were evaluated as sugarcane ripeners and compared with the labeled ripeners glyphosine and glyphosate (Polaris and Polado, respectively). At three and five weeks after treatment, fluazifop-butyl at 0.12 and 0.25 lb ai/a increased sucrose content as effectively as 2.12 lb ai/a of glyphosine. Neither sethoxzydim at 0.25 nor fluazifop-butyl at 0.06 lb ai/a was as effective as glyphosine in increasing sucrose content. The fluazifop-butyl and sethoxydim treatments gave superior early stubble regrowth when compared to the standard glyphosate treatment of 0.31 lb ae/a.

INTRODUCTION

In recent years the sugarcane ripeners glyphosine (Polaris) and glyphosate (Polado) have been applied to a majority of the cane harvested in Florida during the first two or three months of the grinding season. However, glyphosine cannot be applied after December 15, 1985, due to registration revocation and glyphosate is labeled for only the last stubble crop since it has been shown to reduce cane tonnage in the succeeding crop (3). Accordingly, additional ripening compounds are needed. The grass herbicides fluazifop-butyl and sethoxydim are known to have some of the properties which are characteristic of ripeners: 1) both interrupt terminal growth, 2) both are relatively slow in killing the plants, and 3) both cause no direct or immediate interruption of photosynthesis. Dusky (1) reported a significant response to 0.5 lb ai/a fluazifop-butyl when brix and percent sucrose were measured five weeks after treatment. Sethoxydim at 0.037, 0.075 and 0.150 lb ai/a increased sugar/ton of cane four weeks after treatment in the plant cane crop, but had no effect on second stubble cane. Legendre (2) obtained a ripening response to 0.28 kg ai/a of fluazifop-butyl in six of seven varieties in Louisiana. However, glyphosate at 0.34 kg ae/a was more effective than fluazifop-butyl with less loss of stalk weight. Fusilade is labeled for application in South Africa at rates less than those used by Dusky (1). No information was found in the literature concerning stubble regrowth following application of fluazifop-butyl or sethoxydim. This study was conducted to compare the sugarcane ripening properties of fluazifop-butyl and sethoxydim and their effect on stubble regrowth with those of glyphosine and glyphosate.

MATERIALS AND METHODS

Fluazifop-butyl and sethoxydim were applied to second stubble cane of six sugarcane varieties, CL 54-378, CL 59-1052, CL 61-620, CL 65-294, CP 70-1133, and CP 72-1210, for a preliminary evaluation of the chemicals as sugarcane ripeners. The labeled ripeners glyphosine and glyphosate were included as standards for comparison. The experimental design was a split-plot with ripener treatments as whole plots and varieties as subplots. Glyphosine at 2.12 lb ai/a (the recommended rate); fluazifop-butyl at 0.06, 0.12 and 0.25 lb ai/a; and, sethoxydim at 0.12 and 0.25 lb ai/a were applied to the cane in 10 gal/a water containing 0.25% of the surfactant Induce on October 10, 1984. Glyphosate applications at 0.16, 0.24 and 0.31 lb ae/a in 10 gal/a water containing 0.25% Induce were delayed until October 22, 1984. Glyphosate is recommended for application three to five weeks before harvest, while glyphosine is applied five to eight weeks before harvest; thus, the delay allowed a uniform harvest date. Three plots of each variety were treated, resulting in 18 plots for each treatment and 18 untreated control plots.

Juice analyses were conducted on October 31 on hand-cut samples and November 12-13, 1984, three and five weeks after treatment, respectively. Plots treated with glyphosate were sampled only on November 12-13, 1984, three weeks after treatment. Ten stalks from the center rows were hand-cut, stripped, topped at the apex, and milled in a three-roll mill. Juice brix and pol were measured to calculate yield of 96° sugar/ton of cane expressed as sugar percent cane (sugar/ton ÷ 2000) or percent yield. The test was burned November 18 and hand-cut November 19 and 20, 1984. Cane in the two middle rows (0.01 a) was weighed to determine tons of cane per acre (TCA).

The effect of treatments on regrowth was studied. Shoot counts were made two and six weeks after harvest and compared with stalk counts which were made six weeks before treatment (August, 1984). During January 17-24, 1985, new shoots were cut from three feet of row in each plot, counted, dried, and weighed. The average shoot weight was calculated.

RESULTS AND DISCUSSION

No variety X treatment interaction was detected; therefore, means reported are an average of all six varieties. Fluazifop-butyl at 0.12 or 0.25 lb ai/a was as effective as 2.12 lb ai/a glyphosine in improvement of % yield (Table 1).

Table 1. Sugar percent cane, shoot counts, and shoot weights averaged over six sugarcane varieties treated with glyphosine, fluazifop-butyl, sethoxydim or glyphosate[1].

Treatment	Rate lb ai per acre[2]	Yield of 96° sugar % cane 10/31/85	11/13/85[3]	Regrowth Shoots/a (1000) Weeks after harvest[4] two	six	Shoot[5] wt (g)
Check	----	9.46	10.02	22.2	34.6	1.7
Glyphosine	2.12	10.89	11.94	16.8	30.6	1.1
Fluazifop-butyl	0.25	10.87	11.81	27.2	37.3	1.8
Fluazifop-butyl	0.12	10.88	11.95	26.9	39.9	2.4
Fluazifop-butyl	0.06	10.51	11.44	22.5	38.3	2.1
Sethoxydim	0.25	10.61	11.60	22.2	39.3	2.6
Sethoxydim	0.12	10.15	11.28	20.0	33.5	3.2
Glyphosate	0.31	---	11.90	9.6	15.5	1.0
Glyphosate	0.24	---	11.44	10.2	18.9	0.8
Glyphosate	0.16	---	11.39	19.2	28.5	1.5
LSD	.01	.89	1.14	11.3	9.7	1.0

[1]Three plots of each of six varieties (18 total plots) CL 54-378, CL 59-1052, CL 61-620, CL 65-294, CP 70-1133, and CP 72-1210 were treated on October 10 1984, except glyphosate treatments applied October 22, 1984. Ten-stalk samples were harvested from each plot.

[2]Active ingredient applied in 10 gallons of water per acre with 0.25% of the surfactant Induce. Glyphosate rates as acid equivalent.

[3]Sampled on November 13, 1985, five weeks after treatment, except three weeks after glyphosate treatments.

[4]Harvested on November 19, 1984; counts December 5, 1984, and January 2, 1985.

[5]Average dry weight/shoot (grams) on January 17, 1985, eight weeks after harvest.

These two fluazifop-butyl treatments were 15% and 19% higher in % yield than the untreated checks at three and five weeks after treatment, respectively. Sethoxydim (average of 2 rates) increased % yield over the untreated checks 9.7% and 14.2% at three and five weeks after treatment, respectively. Glyphosate, when applied at the recommended rate of 0.31 lb ae/a and harvested in 3 weeks, was equivalent to glyphosine applied at 2.12 lb ai/a and harvested at 5 weeks. Fluazifop-butyl at 0.06 lb ai/a and glyphosate at 0.16 or 0.24 lb ae/a were approximately 75% as effective as the recommended rates of both glyphosine and glyphosate.

Cane yields from all plots produced an average of 46 tons cane per acre (TCA), indicating reasonable growth for second stubble cane. There were no differences in TCA attributed to treatments.

Extreme reductions in the rate of stubble regrowth, as judged by number of shoots per acre or average shoot size following treatment with glyphosine and glyphosate at the recommended rates, have been related to measurable reductions in TCA six to ten months after treatment (3, E. C. Watson, unpublished data)). As in previous tests, the typical retarding effect of these two labeled ripeners was evident (Table 1). However, an increase in shoot counts was noted for both fluazifop-butyl and sethoxydim at two or six weeks after harvest. Also, shoot weight was higher at two months after harvest. It is apparent that the treatments were responsible for the trends since the pre-treatment counts in August 1984 showed no significant differences in number of stalks between plots.

SUMMARY

The grass herbicide fluazifop-butyl at 0.12 or 0.25 lb/a was as effective in ripening sugarcane as the standard ripeners glyphosine and/or glyphosate. Sethoxydim was effective at rates of 0.12 and 0.25 lb ai/a, but not as effective as fluazifop-butyl. Neither fluazifop-butyl nor sethoxydim retarded stubble regrowth; in fact, they appeared to enhance early regrowth. Plots treated with either glyphosate or glyphosine had delayed regrowth as judged by shoot counts two and six weeks after harvest and average shoot weight two months after harvest.

Fluazifop-butyl appears to merit additional testing as a ripener with emphasis on rates of 0.05 to 0.2 lb/a.

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EVALUATION OF SACCHARUM AND RELATED GERMPLASM FOR TOLERANCE TO HIGH WATER TABLE ON ORGANIC SOIL[1/]

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ABSTRACT

The organic soil (Histosol) in the Everglades Agricultural Area of Florida is subsiding at a rate of about 2.5 cm per year. As subsidence continues, sugarcane (Saccharum spp.) will be grown on progressively shallower and wetter soils. At present, raising the water table is the only practical means of reducing subsidence. Identification and selection of sugarcane germplasm tolerant to high water table (HWT) are urgently needed. In this study, we report comparative performance of sugarcane and related germplasm under HWT and normal water table (NWT) conditions on organic soil.

Nineteen clones of Saccharum sp. and one of Ripidium sp. (IK 76-63) were planted in a HWT field and in a NWT field in January 1982. The water table was monitored at weekly intervals. The mean water table based on monthly averages during the test period was 29.8 cm (standard deviation = 15.0) in the HWT field and 56.2 cm (standard deviation = 7.6) in the NWT field. Ten-stalk samples per plot were harvested in October 1982, November 1982, and March 1983 in the plant-cane crop. Harvest was done only once (October 1983) in the first-ratoon crop. For each sample, crusher juice was analyzed for Brix and percentage sucrose. Sugar concentration (SC expressed as grams of sugar per kg of cane) and total plot weight were determined. The percentage difference (PD) for a trait of a clone in the HWT field and in the NWT field was computed as: PD = [(Trait value in HWT field/Trait value in NWT field) - 1] x 100.

For the October harvest dates in the plant-cane and ratoon crops, clones CO 419, CP 56-59, CP 63-306, CP 65-357, CP 69-1052, CP 70-1527, CP 74-2005, CP 75-1632, and NG 77-59 had relatively higher SC under HWT conditions in both crops. CO 419 had the highest PD for mean stalk weight in the two crops, followed by NG 77-59 and CP 69-1052. The PD for plot weight was the highest in the two crops for CP 69-1052, followed by CP 63-306, CO 419, CP 62-374, NG 77-136, NG 77-59, Mex 57-473, and CP 65-357. The lowest PD for plot weight was for CP 72-2086. IK 76-63 and CP 74-2005 had higher plot weight in the NWT field in both crops. It is proposed that the differential water table in the two fields caused the difference in performance of a clone in the two fields.

INTRODUCTION

Sugarcane (Saccharum spp.) is the major crop grown in the Florida Everglades Agricultural Area (EAA) on about 141,750 hectares primarily of organic soil (Histosol). Organic soil is subsiding at the rate of about 2.5 cm per year and it has been estimated that by the turn of the century, about 202,500 hectares (87% of the total) of organic soil in the EAA will be 0.92 m or less in thickness, and over 101,250 hectares will be less than 0.31 m (9). By 1990, a considerable area of organic soils will be very shallow and may be abandoned for sugarcane production because of soil subsidence (9). High-water-table-tolerant cultivars of sugarcane are desired for two reasons: 1) as subsidence continues, sugarcane will be grown on shallower and, therefore, wetter soils, and 2) raising the water table is the only practical way of reducing subsidence and preserving the organic soil (9). Therefore, a major emphasis is needed on development of sugarcane cultivars and germplasm evaluation under high water table conditions.

Very little information is available on the field performance of sugarcane clones under high water table conditions on organic soils. A water table depth of 75 cm produced the best tonnage of sugar per unit area for four clones, but

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production was only reduced by 5% with a 37 cm water table on muck (6). Escolar et al. (2) indicated that cultivars of sugarcane differed in their reaction to water table conditions and that clone PR 980 yielded more cane and available sugar as the water table was lowered. Juang and Uehara (4) studied performance of sugarcane at 80, 50, and 30 cm water table depths in ceramic pots filled with a sandy loam or clay loam soil, and indicated that sugarcane performed best in water table treatment of 80 cm.

From lysimeter studies, Shih and Gascho (7) concluded that high water tables in the initial and grand growth periods of sugarcane significantly reduced sugarcane production on organic soils. In another lysimeter study, Shih and Gascho (8) indicated that more water was required in the dry season and grand growth period of sugarcane for a high water table than for a low water table on organic soil.

The purpose of this investigation was to compare performance, in the field, of several sugarcane clones and related germplasm under high water table and normal water table conditions on organic soil.

MATERIALS AND METHODS

Seventeen clones of sugarcane (*Saccharum* sp.), one of *S. robustum* (NG 77-136), one of *S. officinarum* (NG 77-59), and one of *Ripidium* sp. (IK 76-63) were planted at the Everglades Research and Education Center, Belle Glade, Florida on January 12, 1982, in each of two fields. One field (previous crop was rice, *Oryza sativa* L.) represented high water table (HWT) conditions and the other field represented normal water table (NWT) conditions. Both fields had Pahokee muck soil (a Euic, hyperthermic Lithic Medisaprist) (9). Half of the plots in the HWT field had a previous application of silicate slag to the rice crop. In the HWT field, the 20 clones were replicated twice each on the silicate slag-applied plots and on those without a previous silicate slag application. Unfortunately, additional rice fields were not available for use as HWT treatment. In the NWT field, clones were replicated twice but only on a soil with no previous application of silicate slag. In both fields, a randomized complete block design was used. Planting was achieved by placing 5 stalks of cane in open furrows for each single-row plot, 4.57 m long, with 1.5 m spacing between plots, which gave a plot size of 0.0006855 ha.

Three polyvinyl chloride (PVC) pipes of 3.21 cm diameter were installed in the middle of the HWT field and two in the middle of the NWT field. Following germination, water table was monitored in the PVC pipes (pipes were perforated to ensure equilibrium of water inside and outside the pipes) in the two fields at weekly intervals. In the HWT field, the mean water table based on monthly averages during the 21-month test period was 29.8 cm below the soil surface (standard deviation of 15.0), and in the NWT field, the mean water table for the same period was 56.2 cm below the soil surface (standard deviation of 7.6). The HWT field was in the middle of two rice fields which were often flooded. Thus a relatively high water table was maintained in the HWT field. In addition, water was supplied through irrigation ditches on either side of the HWT field.

Ten-stalk samples per plot were harvested on each of the following dates: October 15 and November 30, 1982, and March 3, 1983. Each sample was weighed and milled, and crusher juice was analyzed for Brix (percentage soluble solids) and percentage sucrose. Sugar concentration (SC), expressed as grams of sugar per kilogram of cane (5), was calculated by using Arceneaux's modification of the Winter-Carp-Geerligs formula (1). Total number of stalks was counted at the final harvest (March 3). Total plot weight (in kg) was determined by multiplying the total number of stalks per plot by the mean stalk weight. Percentage purity was calculated as (Sucrose/Brix) x 100.

All plant-cane plots were allowed to ratoon. For the ratoon crop, the number of millable stalks per plot was recorded in August 1983. A ten-stalk sample per plot was cut only once in October 1983. Mean stalk weight, total plot weight, Brix, percentage sucrose, SC, and percentage purity were determined in the same manner as in the plant-cane crop. For each crop, analyses of variance were computed separately for HWT and NWT environments. The percentage difference (PD) for a trait of a clone in the HWT field and NWT field was computed as: PD = [(Trait value in HWT field/Trait value in NWT field) - 1] x 100.

This computation is similar to that used by Froehlich and Fehr (3) for calculating percentage difference in soybean [*Glycine max* (L.) Merr.] performance on calcareous soil vs. noncalcareous soil.

RESULTS AND DISCUSSION

Analyses of variance (AOV) showed that for the plant-cane (PC) crop in the HWT field, variation was significant due to clones and harvest dates for Brix, percentage sucrose, SC, percentage purity, and mean stalk weight (Table 1), and due to clones for stalk number and plot weight (AOV not shown). Residual effect of silicate slag was not appreciable for any trait in plant cane. Clone X silicate interaction was significant only for Brix, and clone X date interaction was significant for Brix, percentage sucrose, SC, and percentage purity. Clone X date interaction was not involved in the AOV for stalk number and plot weight because these two traits were measured only once. For the traits studied, residual effect of silicate applied to the previous crop of rice was not carried over to the next crop of sugarcane.

Table 1. Weighted analyses of variance for plant cane Brix, percentage sucrose, sugar concentration (SC), percentage purity, and mean stalk weight under high water table conditions.

Source	df	Mean Square Brix	Sucrose	SC	Purity	Mean Stalk Wt.
		%	%	g kg^{-1}	%	kg
Replication	1	1.283	0.0002	13.13	11.94	0.008
Silicate (S)	1	0.069	0.877	81.92	18.17	0.181
Clones (C)	19	50.576**1/	93.974**	6479.09**	836.72**	1.542**
Dates (D)	2	43.809**	173.585**	14014.01**	2365.98**	1.658**
S X C	19	3.103**	2.792	167.25	32.89	0.090
S X D	2	0.290	0.106	23.99	10.92	0.050
C X D	38	3.589**	5.895**	465.33**	114.15**	0.068
C X D X S	34	1.300	1.494	97.73	14.16	0.051
Residual	100	1.389	2.225	165.67	38.60	0.054

1/** Significant at the 1% level of probability.

For the plant-cane crop in the NWT field, variation due to clones was significant for all traits (Table 2; AOV not shown for stalk number and plot weight). Dates were significant for all the sugar traits, viz., Brix, percentage sucrose, SC, and percentage purity (Table 2). Clone X date interaction was significant for sucrose, SC, and percentage purity (Table 2).

Table 2. Weighted analyses of variance for plant cane Brix, percentage sucrose, sugar concentration (SC), percentage purity, and mean stalk weight under normal water table conditions.

Source	df	Mean Square Brix	Sucrose	SC	Purity	Mean Stalk Wt.
		%	%	g kg^{-1}	%	kg
Replication	1	1.08	0.81	39.45	20.33	0.001
Clones (C)	18	15.77**1/	29.97**	2084.96**	342.32**	0.490**
Dates (D)	2	70.74**	150.91**	10767.66**	1460.35**	0.070
C X D	35	2.26	5.29**	402.49**	88.34**	0.040
Residual	38	1.43	1.96	140.12	33.27	0.040

1/** Significant at the 1% level of probability.

For the ratoon crop (RT) in the HWT field, variation due to clones only was significant for all traits (AOV not shown). Silicate X clone interaction was not significant, indicating that all clones responded in a similar manner on silicate plots as on non-silicate plots for all traits.

Since, in general, most interactions were nonsignificant for most traits, we compared the mean performance of the clones under HWT and NWT environments. Percentage differences (PD) in performance in the HWT and NWT fields calculated for SC, mean stalk weight, and plot weight for both plant cane and ratoon crops are shown in Table 3. For SC, results are shown for the means over three sampling dates and means for the early sample (October 1982) in the plant cane crop, and for the only sampling date in the ratoon crop (October 1983). The PD's for 3-date means and for the October 1982 date were, in general, in good agreement. A valid comparison can be made between the October 1982 (plant cane) date and the October

1983 (ratoon crop) date. A positive value indicates percent advantage of a clone grown in the HWT field over that grown in the NWT field, and a minus sign indicates percent disadvantage. CP 72-1210 had poor germination and was not included in the analyses.

Table 3. Mean performance of *Saccharum* and related germplasm under normal water table (NWT) and high water table (HWT) conditions and percentage difference† (PD) in performance for sugar concentration (SC), mean stalk weight, and plot weight in plant cane (PC) and ratoon (RT) crops.

	SC ($g\ kg^{-1}$)									Mean stalk weight (Kg)						Plot weight‡ (Kg)					
	PC Mean (3 dates)			PC (Oct. 82)			RT (Oct. 83)			PC			RT			PC			RT		
Clone	HWT	HWT	PD	HWT	HWT	PD	HWT	HWT	PD	HWT	HWT	PD	HWT	HWT	PD	HWT	HWT	PD	HWT	HWT	PD
CO 419	57.4	82.4	43.6	27.4	45.3	65.3	22.1	51.0	130.8	1.41	1.63	15.6	0.64	1.74	171.9	50.9	64.1	25.9	24.1	83.1	244.8
CP 56-59	82.9	103.5	24.8	64.6	86.1	33.3	76.4	87.8	14.9	1.23	1.54	25.2	1.08	1.40	29.6	49.1	51.8	5.5	63.1	41.8	- 33.8
CP 62-374	72.6	112.6	55.1	57.5	89.4	55.5	62.1	60.0	- 3.4	1.59	2.13	34.0	1.43	1.63	14.0	41.5	96.7	133.0	48.6	79.5	63.6
CP 63-306	90.6	102.0	12.6	52.8	90.3	71.0	66.8	83.9	25.6	0.86	1.27	47.7	0.84	1.01	20.2	21.8	51.2	134.9	22.2	73.5	231.1
CP 63-588	99.9	96.1	- 3.8	84.1	70.9	-15.7	85.4	84.8	- 0.7	1.14	1.00	-12.3	1.07	1.35	26.2	28.7	25.3	-11.8	40.9	41.8	2.2
CP 65-357	93.2	116.2	24.7	59.8	117.6	96.7	76.6	94.7	23.6	1.04	1.27	22.1	0.96	1.02	6.3	31.9	71.9	125.4	63.6	77.2	21.4
CP 69-1052	94.1	109.4	16.3	71.6	104.6	46.1	69.6	96.9	39.2	1.14	1.54	35.1	0.84	1.53	82.1	31.5	84.2	167.3	30.0	94.9	216.3
CP 70-1133	89.7	108.5	21.0	64.4	98.1	52.3	80.9	77.0	- 4.8	1.18	1.41	19.5	1.36	1.46	7.4	59.7	65.6	9.9	109.9	109.0	-0.8
CP 70-1527	92.6	106.2	14.7	76.7	85.8	11.9	71.0	85.1	19.9	1.41	1.59	12.8	1.04	1.64	57.7	50.7	52.4	3.4	108.1	67.2	37.8
CP 72-2086	105.8	118.3	11.8	88.7	101.5	14.4	78.7	74.5	- 5.3	1.18	1.50	27.1	1.27	1.33	4.7	50.2	60.2	19.9	85.4	87.2	2.1
CP 73-1547	111.6	117.9	5.6	104.1	113.5	9.0	86.6	115.7	33.6	1.32	1.36	3.0	1.11	1.81	63.1	40.4	31.7	-21.5	44.9	55.8	24.3
CP 74-2005	86.8	126.9	46.2	62.9	116.7	85.5	68.6	93.9	36.9	1.09	1.27	16.5	1.42	1.24	-12.7	120.6	71.8	-40.5	136.2	118.0	-13.4
CP 75-1091	98.4	110.5	12.3	89.7	99.3	10.7	77.1	78.4	1.7	1.50	1.63	8.7	1.39	1.48	6.5	77.5	95.7	23.5	145.3	122.6	-15.6
CP 75-1553	103.5	120.4	16.3	77.0	106.8	38.7	95.2	91.6	-3.8	1.04	1.18	13.5	1.50	1.17	-22.0	36.5	54.8	50.1	79.9	61.3	-23.3
CP 75-1632	96.2	110.7	15.1	86.9	106.6	22.7	71.7	91.6	27.8	1.23	1.63	32.5	1.43	1.65	15.4	36.5	56.8	55.6	56.8	73.1	28.7
IK 76-63	73.3	35.1	-52.1	0.0	3.9	0.0	0.0	36.2	0.0	0.59	0.41	-30.5	0.44	1.17	165.9	36.9	19.5	-47.2	40.4	35.9	-11.1
Mex 57-473	60.7	68.2	12.4	38.7	42.8	10.6	62.1	42.9	-30.9	0.91	1.14	25.3	0.80	1.14	42.5	48.0	72.7	51.5	72.6	158.9	118.9
NG 77-59	54.9	61.3	11.7	20.7	26.8	29.5	19.0	38.4	102.1	0.50	0.73	46.0	0.54	1.20	122.2	36.2	53.8	48.6	52.2	122.6	134.9
NG 77-136	36.3	43.9	20.9	43.7	32.8	-24.9	43.1	42.9	- 0.5	0.41	0.59	43.9	0.45	0.63	40.0	30.4	41.0	34.9	23.6	60.4	155.9
Overall $\overline{X}$	84.2	97.4	15.7	61.6	81.0	31.5	63.8	75.1	17.6	1.09	1.31	20.2	1.03	1.35	30.8	46.3	59.0	27.5	65.7	-82.3	25.3

† A positive value indicates percent increase for a clone grown on HWT over that grown on NWT and a negative value indicates percent decrease when grown on HWT.

‡ A plot = 0.0006855 ha.

It should be noted that since the HWT and NWT trials were in two separate fields, differences for any trait can only be declared between the fields. However, we propose that the water tables caused the differences, as water table depth was the only major difference between the two fields.

Since SC is a function of Brix and percentage sucrose, hereafter, the latter traits will not be discussed separately. All clones except CP 75-1553, CP 70-1133, CP 72-2086, NG 77-136, CP 62-374, and Mex 57-473 had consistently higher SC in the HWT field in both plant cane and ratoon crops. CP 63-588 had lower SC in the HWT field in both crops. Overall, CO 419 had the highest percent increase in SC over two crops, followed by NG 77-59 and CP 74-2005.

For mean stalk weight, 15 clones performed better under HWT environment in both crops. The highest 2-crop performance was shown by CO 419, followed by NG 77-59 and CP 69-1052. Clones CP 75-1553, CP 74-2005, CP 63-588, and IK 76-63 were inconsistent in the two crops. The performance of CP 70-1133 was low but consistent between PC and RT.

Plot weight is the product of total stalk number and mean stalk weight for a plot. Therefore, the clones which had the highest mean stalk weight under HWT conditions did not necessarily have the highest plot weight. CP 69-1052 had the highest plot weight in two crops, followed by CP 63-306, CO 419, CP 62-374, NG 77-136, NG 77-59, Mex 57-473, and CP 65-357. The lowest consistent plot weight over two crops was that of CP 72-2086. Eight clones were inconsistent for plot weight in

the two crops. IK 76-63 was the only clone which had higher plot weight under NWT conditions in both crops. Plot weight would be an important characteristic from the total biomass standpoint. This information would be helpful in identifying the clones which perform better under HWT conditions on organic soils.

From a breeding standpoint, selection of parents that performed better in the HWT field would aid in developing sugarcane cultivars that have the ability to do well under HWT conditions. Crosses can be made between those clones which displayed tolerance to high water table conditions. The progeny of these crosses may be expected to be HWT-tolerant depending upon heritability of the clonal response to high water table which needs to be determined.

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ALTERNATIVE METHODS OF ESTIMATING YIELDS OF SUGARCANE IN RESEARCH PLOTS

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ABSTRACT

The quantity of agricultural research in sugarcane (Saccharum spp.) is limited by the time and expense needed to measure yields by cutting and weighing entire research plots. The objective of this three-year study was to compare alternative methods of measuring yields with the standard method of weighing entire research plots to estimate millable cane tonnage and randomly selecting samples of 15 stalks to estimate sugar concentration. Data were collected from a standard clone performance trial at four locations. To estimate alternative cane and sugar yields, stalks predicted to be millable from November through March were counted in the preceding June and August, and stalk samples from five to thirty in number, in intervals of five, were analyzed at harvest. In general, sugar concentration estimates were not reliable with samples of less than ten stalks, but little improvement was obtained by sampling more than 15 stalks. Correlations of the standard and alternative methods for measuring cane yield were reasonably high in two of the three crop cycles (plant and second-ratoon crops). As with sugar concentration, samples of more than 15 stalks did not substantially increase reliability of measurements. Both June and August were acceptable months in which to make stalk counts to be used in yield estimation. Conclusions were in agreement with previous studies that the alternative methods were acceptable, but the level of confidence obtained was not as high as with the standard method.

INTRODUCTION

Measuring yields in small plots of field experiments of sugarcane (Saccharum spp.) is often difficult. A standard procedure used by many sugarcane researchers is to cut all of the cane manually in each plot and weigh it with a tractor-mounted device designed specifically for weighing sugarcane. To prepare a normal experiment in Florida of about 0.3 ha for sampling and weighing, 40 to 56 work-hours are required to appropriately cut and pile the cane stalks. An additional 16 to 40 work hours are needed to collect samples and weigh the cane. When sugarcane is cut manually in Florida, four rows of cane are piled together in one "pile row." Thus, border rows are often not used to separate plots because in an experiment with four-row plots, use of border rows would double the size of the experiment. Also, the job of cutting sugarcane is hard, dirty, seems to require special skills and generally does not pay well. Since it is difficult to find workers willing and able to accept such a job, in many regions where sugarcane is grown, mechanical harvesters are used. Although mechanical harvesters are used successfully to cut sugarcane in research plots in some areas, no mechanical harvester has been widely used for this purpose in Florida. For the above reasons, alternate methods of obtaining reliable measurements of sugarcane yield in research plots have been studied by a number of researchers.

In Louisiana, Hebert (5) and Fanguy (3) found significant correlations between cane yields measured by weighing entire plots and those estimated by multiplying number of counted stalks per plot by the average stalk weight obtained from samples of 10 and 20 stalks. In general, these two studies concluded that the estimated yields were usable, but the procedure of weighing entire plots was preferable.

In a nitrogen fertility experiment in Texas, Thomas and Oerther (10) determined, through the use of aerial photography, that decreases in yield associated with nitrogen stress caused changes in canopy reflectance. Also, sugarcane yields were significantly correlated with percent transmission of light. However, this technique has not been sufficiently quantified or tested to recommend its use with other experimental treatments (such as clones).

Hogarth and Skinner (6) published a comprehensive report on different methods of yield estimation in Austrailia where machine harvesting had completely replaced manual harvesting in commercial fields. In a series of experiments conducted over

six years, they tested six alternative methods of estimating cane yields. The best alternative method was to multiply mean stalk weight of a sample of 45 to 60 stalks by stalk number counted at time of harvest. Three methods - visual estimates, the use of a few stalks subjectively selected as typical of a plot, and stalk volume measurement - were determined to be unsuitable.

A secondary objective of a study conducted in Florida by Kang et al. (7) was to determine whether cane yields could be reliably estimated by multiplying number of stalks by the mean stalk weight of a 10-stalk sample. They found a high correlation and similar path coefficients between yields measured by weighing entire plots and those estimated by the alternative method. They concluded that yields estimated by the alternative procedure would be adequate.

The major objectives of this study were to determine for the final stage replicated cultivar experiments in Florida, the minimum number of stalks per sample necessary to reliably determine sugar concentration, and to evaluate other methods of estimating cane yield. A secondary objective was to compare June and August stalk counts for reliability in estimating cane yields.

MATERIALS AND METHODS

A standard yield trial with 11 promising sugarcane clones and one commercial clone was planted in the fall of 1980 at four Florida locations, Beardsley Farms near Lake Harbor; A. Duda and Sons' Farm east of Belle Glade; New Farm, Inc., east of Canal Point; and South Florida Industries near 20-mile Bend in Palm Beach County. The soils at Duda and New Farm were Lauderhill muck, and at Beardsley and South Florida Industries were Torry muck and Terra Ceia muck, respectively.

In each experiment, clones were planted with two lines of seed cane per furrow in four-row plots of 0.0065 ha (10.68 m long with 1.52 m between rows) in a randomized complete-block design with four replications. Only the first two replications at each location were used in this study. Further information about these trials can be found in Glaz et al. (4).

From each plot, estimates by different methods were made of tonnes per ha of cane (THC), sugar concentration (SC) measured as kg sugar per tonne of cane, and tonnes per ha of sugar (THS) which equaled (THC x SC)/1000. Two general methods of estimating THC were tested. The first, referred to hereafter as the standard method, was by weighing the cut cane in entire plots. The second was to multiply number of stalks considered millable from counts in June or August by the average stalk weight estimated from harvest samples of five to thirty stalks. All stalk samples used were selected randomly from the middle of the plots after the cane had been cut and were of undamaged, millable stalks. SC was calculated by using Arceneaux's modification of the Winter-Carp-Geerligs formula (1) and was expressed as kg of sugar per tonne of cane. Thus, the following estimates were made of SC, THC, and THS in plant crop, first-ratoon crop, and second-ratoon crop.

I. Plant crop.

A. Sample size used to estimate SC.

1. Sample of 5 stalks.
2. Sample of 10 stalks.
3. Sample of 15 stalks.
4. Sample of 20 stalks (the weighted average of the samples of 5 and 15 stalks[1/]).
5. Sample of 25 stalks (the weighted average of the samples of 10 and 15 stalks).
6. Sample of 30 stalks (the weighted average of the samples of 5, 10 and 15 stalks).

[1/]Using SC of the 20-stalk sample as an example, weighted averages of SC were calculated as follows: SC of 20-stalk sample = [(SC of 5-stalk sample X weight of 5-stalk sample) + (SC of 15-stalk sample X weight of 15-stalk sample)]/(weight of 5-stalk sample + weight of 15-stalk sample).

B. Methods used to estimate THC.

1. Weight of entire plot converted to tonnes ha^{-1}.

2. Mean weight per stalk of 5-stalk sample (W_5) X number of stalks per ha, counted in August preceding harvest (#Aug).

3. Mean weight per stalk of 10-stalk sample (W_{10}) X #Aug.

4. Mean weight per stalk of 15-stalk sample (W_{15}) X #Aug.

5. Mean weight per stalk calculated from the weighted average of W_5 and W_{15} (W_{20}) X #Aug.

6. Mean weight per stalk calculated from the weighted average of W_{10} and W_{15} (W_{25}) X #Aug.

7. Mean weight per stalk calculated from the weighted average of W_5, W_{10}, and W_{15} (W_{30}) X #Aug.

C. Methods used to estimate THS.

1. The standard THS which was SC from 15-stalk sample X weight of entire plot converted to ha.

2. All SC estimates of a particular sample size were multiplied by the THC estimates of the same sample size.

II. Ratoon crops.

A. All estimates were made as in the plant crop. In addition, stalk counts were also made in June, so THC and THS estimates were made from early (June) stalk counts and from late (August) stalk counts.

All correlation coefficients (r) and means were calculated using the PROC CORR procedure of SAS (8). Each r value was calculated from 96 observations (2 replications X 12 clones X 4 locations). With n - 2 = 94 df, the 0.05 and 0.01 significance levels were r = 0.254 and 0.312, respectively. Spearman's coefficient of rank correlation (r_s) was calculated as described by Steel and Torrie (9).

RESULTS AND DISCUSSION

Correlations between the different sample sizes for estimating SC for plant through second-ratoon crop are shown in Table 1. In the plant crop, correlations between all sample sizes were very high, indicating that samples of as few as five stalks were adequate for estimating SC. In the ratoon crops, correlations which involved samples of five or ten stalks were considerably lower. However, correlations of 15-stalk sample SC with SC from samples of greater than 15 stalks were all greater than or equal to 0.90 in all three crops, indicating that little was gained in SC estimates by sampling more than 15 stalks.

The correlations between different harvest methods which used August stalk counts to estimate THC are shown in Table 2 for the three crops. The plant-crop correlations were excellent for all sample sizes, the second-ratoon correlations were acceptable, and the first-ratoon correlations were relatively low. In general, the correlations of THC estimates using samples of five stalks with the estimates using the standard method were lower than those between the standard method and other methods which used stalk samples of at least 10 stalks. The increase in r was slight when stalk size was increased from 10 to 15 stalks, and of no importance when stalk size was increased from 15 to 20 stalks. Thus, when using an alternative method to estimate THC, at least 10 stalks should be sampled to estimate stalk weight, but little gain would be expected by estimating stalk weight with more than 15 stalks.

Table 1. Plant-crop through second-ratoon crop correlation coefficients (r) of sugar concentration measurements from samples of varying stalk number.

Sample size (No. stalks)	Sample size (No. stalks) 5	10	15	20	25	30
	r					
			Plant crop			
5	1.00	0.90	0.84	0.91	0.89	0.93
10		1.00	0.88	0.91	0.96	0.96
15			1.00	0.99	0.98	0.97
20				1.00	0.99	0.99
25					1.00	1.00
30						1.00
			First-ratoon crop			
5	1.00	0.50	0.45	0.73	0.53	0.71
10		1.00	0.60	0.64	0.85	0.84
15			1.00	0.94	0.93	0.90
20				1.00	0.91	0.96
25					1.00	0.97
30						1.00
			Second-ratoon crop			
5	1.00	0.64	0.65	0.81	0.70	0.80
10		1.00	0.68	0.72	0.89	0.88
15			1.00	0.97	0.94	0.93
20				1.00	0.94	0.96
25					1.00	0.99
30						1.00

Table 2. Plant-crop through second-ratoon crop correlation coefficients (r) of cane yield measured by the standard and alternative methods.

Sample size (No. stalks)	Sample size (No. stalks) 5	10	15	20	25	30
	r					
			Plant crop			
Standard method	0.75	0.78	0.84	0.85	0.86	0.86
5	1.00	0.77	0.80	0.89	0.83	0.89
10		1.00	0.80	0.82	0.92	0.92
15			1.00	0.98	0.97	0.96
20				1.00	0.97	0.98
25					1.00	0.99
30						1.00
			First-ratoon crop			
Standard method	0.49	0.60	0.63	0.63	0.65	0.64
5	1.00	0.76	0.72	0.85	0.78	0.85
10		1.00	0.81	0.85	0.94	0.94
15			1.00	0.98	0.96	0.95
20				1.00	0.97	0.98
25					1.00	0.99
30						1.00
			Second-ratoon crop			
Standard method	0.71	0.75	0.78	0.80	0.79	0.80
5	1.00	0.85	0.80	0.88	0.84	0.89
10		1.00	0.92	0.92	0.96	0.96
15			1.00	0.99	0.98	0.99
20				1.00	0.98	0.99
25					1.00	0.99
30						1.00

In the two ratoon crops, estimates of THC were compared from stalk counts made in June with stalk counts made in August (Table 3). Since actual harvest of these plots occurred from the following November through March, these counts were made during the peak of the growing season. Although all correlations are shown in Table 3, the correlations of most interest are those of the same sample size using stalk counts in June vs August. In first ratoon, these correlations were acceptable, and in second ratoon, each r was 0.95, which was excellent. Thus, results were similar, regardless of whether stalk counts were taken early or late. To increase flexibility in the use of these alternative methods of yield estimation, it may be worthwhile to determine if stalk counts taken before June would also be acceptable. Eiland and Dean (2) have shown that relative population differences among treatments remain similar from 40 to 320 days after planting sugarcane.

Table 3. First and second-ratoon crop correlation coefficients (r) of cane yield measured from stalk counts made in June and August preceding harvest.

June Sample size (No. stalks)	August Sample size (No. stalks)					
	5	10	15	20	25	30
	r					
	First-ratoon crop					
5	0.74	0.53	0.45	0.56	0.51	0.57
10	0.46	0.75	0.53	0.55	0.66	0.64
15	0.38	0.53	0.69	0.64	0.65	0.62
20	0.51	0.66	0.65	0.66	0.66	0.65
25	0.44	0.66	0.65	0.63	0.69	0.66
30	0.52	0.66	0.64	0.64	0.68	0.67
	Second-ratoon crop					
5	0.95	0.78	0.74	0.83	0.78	0.83
10	0.83	0.95	0.85	0.88	0.92	0.92
15	0.78	0.63	0.95	0.94	0.93	0.93
20	0.86	0.86	0.93	0.95	0.92	0.93
25	0.82	0.91	0.93	0.94	0.95	0.95
30	0.86	0.91	0.92	0.94	0.94	0.95

The correlations between the different methods for estimating THS are shown in Tables 4 and 5. Results for THS were similar to those for THC.

Spearman's coefficients of rank correlation (r_s) for cultivar rankings (Table 6) were calculated for all three crops for THS to determine if rankings of clones were affected by the various methods of yield estimation. Since June and August rankings were similar, only the r_s values comparing the methods which used August counts with the standard method are shown. A significant r_s was interpreted as indicating that rankings of clones were similar between yield-estimation methods. As with many of the other correlations shown herein, these correlations were high in plant crop, acceptable in second-ratoon crop, and not acceptable in first-ratoon crop. There were no clear indications in the rankings of clones that sample size used to determine SC was important. Variable lodging of different clones in different crops probably affected stalk counts and therefore may be partly responsible for different magnitudes of correlations in different crop years.

The values of r_s in second ratoon would have been excellent except that one clone (CP77-1776) ranked 10th in THS by the standard method and usually 4th or 5th by the alternative methods. In many of the experiments, CP77-1776 incurred more rat damage than some of the other clones. Thus, it is possible that the methods which used stalk counts gave a more accurate prediction of commercial yields that would have been expected with this clone than the yields estimated by weighing the entire plot (since in this case the entire plot had a level of rat damage that would not be expected in commercial fields).

Table 4. Plant crop through second-ratoon crop correlation coefficients (r) of tonnes per hectare of sugar measured by the standard and alternative methods.

Sample size (No. stalks)	Sample size (No. stalks) 5	10	15	20	25	30
	r					
			Plant crop			
Standard method	0.89	0.90	0.96	0.96	0.96	0.96
5	1.00	0.88	0.90	0.95	0.92	0.94
10		1.00	0.91	0.92	0.97	0.97
15			1.00	0.99	0.98	0.98
20				1.00	0.98	0.99
25					1.00	1.00
30						1.00
			First-ratoon crop			
Standard method	0.38	0.59	0.70	0.68	0.70	0.68
5	1.00	0.68	0.60	0.78	0.67	0.78
10		1.00	0.76	0.80	0.92	0.92
15			1.00	0.97	0.95	0.93
20				1.00	0.95	0.73
25					1.00	0.68
30						1.00
			Second-ratoon crop			
Standard method	0.71	0.75	0.80	0.81	0.81	0.81
5	1.00	0.85	0.79	0.88	0.84	0.89
10		1.00	0.88	0.91	0.96	0.96
15			1.00	0.98	0.98	0.97
20				1.00	0.98	0.99
25					1.00	0.99
30						1.00

Table 5. First and second-ratoon crop correlation coefficients (r) of tonnes per hectare of sugar measured from stalk counts made in June and August preceding harvests.

June Sample size (No. stalks)	August Sample size (No. stalks) 5	10	15	20	25	30
	r					
			First-ratoon crop			
5	0.81	0.60	0.39	0.56	0.45	0.55
10	0.46	0.81	0.57	0.59	0.72	0.70
15	0.35	0.53	0.78	0.72	0.72	0.68
20	0.53	0.57	0.75	0.75	0.71	0.72
25	0.43	0.70	0.74	0.71	0.77	0.74
30	0.54	0.70	0.72	0.73	0.75	0.75
			Second-ratoon crop			
5	0.97	0.81	0.75	0.84	0.80	0.85
10	0.85	0.96	0.85	0.89	0.92	0.93
15	0.78	0.84	0.96	0.95	0.94	0.94
20	0.86	0.87	0.94	0.96	0.94	0.95
25	0.83	0.92	0.94	0.95	0.96	0.96
30	0.87	0.92	0.93	0.95	0.95	0.96

Table 6. Spearman's coefficient of rank correlation (r_s) for sugar yield during three crops comparing ranking of clones by alternative methods with the standard method.

	Sample size (No. stalks)					
Crop	5	10	15	20	25	30
	r					
Plant	0.93**[1/]	0.88**	0.89**	0.89**	0.92**	0.95**
First-ratoon	0.40	0.49	0.57*	0.52	0.39	0.42
Second-ratoon	0.80**	0.54	0.70*	0.73**	0.69*	0.72**

[1/]* and ** indicate significance at 5% and 1% probability levels, respectively.

Average THC estimates were calculated to determine if any pattern of over or underestimation compared to the standard method was apparent for the alternative methods (Table 7). In general, in plant and second-ratoon crops, the alternative methods gave higher THC estimates than the standard estimates. In first-ratoon, the THC estimates from the June counts were similar to those of the standard estimate, whereas the estimates from the August counts were lower than those of the standard estimate. All personnel who counted stalks were instructed to count only those stalks which at that time were predicted to be millable. Perhaps in the different crops and at the different counting dates, the impression of what was and was not millable differed enough to account for the differences described above.

Table 7. Means of tonnes per hectare of cane (THC) measured by the standard and alternative methods from plant crop through second-ratoon crop.

Crop	Standard method	From June stalk counts	From August stalk counts
		tonnes ha^{-1}	
Plant	121.43	--	134.65
First-ratoon	118.21	120.24	86.03
Second-ratoon	89.80	112.58	108.06

SUMMARY

A number of different sample sizes and methods were compared for measuring SC, THC, and THS in small plots. The alternative methods compared favorably with the standard method of yield estimation in the plant and second-ratoon crops. However, the alternative methods did not give acceptable estimates in the first-ratoon crop. Since no satisfactory explanation can be given for the poor correlations in first ratoon, our general conclusion is similar to that of Hebert (5) and Fanguy (3) i.e., the alternative methods may be usable but are not preferable. For researchers who use the alternative methods, sample sizes of ten stalks are acceptable, but use of 15-stalk samples appears to be worthwhile. Little is gained by sampling more than 15 stalks. It is not important whether stalk counts are taken in June or August.

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COMPUTERIZED DATA MANAGEMENT IN THE LOUISIANA SUGARCANE BREEDING PROGRAM

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ABSTRACT

The development of software for data management in the Louisiana Sugarcane Breeding program is presented. The software and documentation produced between 1983 and 1985 aids researchers in data entry and analysis specific to the Louisiana breeding program. Routines have been written for analysis using the Statistical Analysis System on Louisiana State University's IBM 3081 mainframe through Time Sharing Option. The use of the System Productivity Facility greatly enhances editing and utility functions. Documentation is available on line to answer questions about software without leaving the terminal.

The application of software is facilitated by organization which parallels stages in the breeding program. These stages include crossing, planting, selection, advancement, assignment and variety testing. Routines and documentation which are specified for each stage are identified by years from crossing.

Data entry and retrieval have some specific functions. Pre-printed forms with concise information assist in planning photoperiod deployment, crossing strategies, and planting and potting schedules. Plot plans are used to generate field maps on which plots to be evaluated are identified. Maps can be updated as new data are entered. Filing routines take care of repetitive tasks in data entry. Computed or summarized data are stored for later use.

Software to assist in the annual production of special reports has been developed. An advancement summary is produced annually for the office report. Advancements from crossing through assignment are summarized by cross, by female parent and by male parent. Assignment means are generated from first and second line trial data. A collection of software to manage data on varieties in active testing (Active File) is another special section that has received much attention. These routines are used to maintain past records and add new data. All data are summarized for varieties active in replicated trials and reported as compared to commercial checks. The Louisiana Sugarcane Variety Advancement Committee uses the final report of the Active File annually to decide which of the experimental varieties will remain in active testing.

INTRODUCTION

Ever since their inception, computers have offered plant breeders opportunity for rapid, efficient data management and utilization. Computerized processing of sugarcane breeding data was pioneered by the HSPA and the BSES breeding programs (4). Analysis and storage of yield data from the Louisiana sugarcane outfield testing program has been computerized since 1976. Major changes in the way people used computers began to take place in the 1970's. The trend of the 1980's has been to develop user-friendly application software. Video terminals and time sharing brought computers to the desktop. In 1983 a mainframe based computerized plant breeding system was developed at Michigan State University (3). That development was closely followed by M-STAT, a microcomputer based application package for plant breeders (2).

The first expansion of the Louisiana sugarcane breeding data management system was implemented by 1982 (6). From 1983 through 1985 the development of additional software and documentation has helped formalize procedures for entering and reporting data in the Louisiana sugarcane breeding program. The purpose of this publication is to report on the progress made in developing a data management system for sugarcane breeding in Louisiana. In the development of this data management system for sugarcane much effort was made to provide external and internal documentation to facilitate application and maintenance of software.

ORGANIZATION

Application of software is facilitated by organization which parallels stages in the breeding program. It takes 14 years from the production of true seed to the release of a new sugarcane variety in Louisiana. Readers who are not familiar

with the Louisiana sugarcane breeding program are directed to Breaux's paper of 1972 (1) for an overview. Stages include crossing, planting seedlings, seedling selection, advancement to 2nd line, evaluation of assignment candidates, assigning permanent variety numbers, and final yield trials. Sugarcane clones are identified by a crossing series, cross number, and plot location until the year of assignment. Each crossing series is represented simultaneously in the breeding program. The number of years form crossing is used to identify each stage. All programs and data dealing with the year of crossing are grouped as type YEAR0. Planting of seedlings is type YEAR1. Selection of single stools is type YEAR2. Advancement from 1st line is type YEAR3. This designation allows quick identification of the crossing series currently associated with any stage in the program. (See Table 1).

Table 1. The year designations for the stages in the Louisiana Sugarcane Breeding Program.

YEAR0	Crosses made
YEAR1	Seedlings established
YEAR2	Selection of seedlings
YEAR3	Advancement to 2nd line
YEAR4	Evaluate candidates
YEAR5	Variety assignment
YEAR6	Exchange varieties
YEAR7	Infield test
YEAR8	Outfield introductions
YEAR9	Outfield test, Increase
YEAR10	Outfield test, Increase
YEAR11	Outfield test, Increase
YEAR12	Outfield test, Increase
YEAR13	Release to sugar industry

The data management system was designed to be used with the System Productivity Facility (SPF) and the Statistical Analysis System (SAS) (5,7). Work done under a project number is placed into a library which is divided into TYPE categories. Each TYPE may have many members, which may be in the form of data, programmed routines or documents. All routines in this data management system have been written in the SAS language.

In the field, data are usually recorded in column format. Data entry following the same format is fast and coding sheets can be dispensed with entirely. Data may be easily entered in column form using SPF, and read as SAS data files. SAS data sets allow easy access for the manipulation of data. Excellent report writing capabilities are also available with SAS.

DATA MANAGEMENT

YEAR0 is the year in which crosses are made. The YEAR0 data base contains all programs and data dealing with the year of crossing. The preparation for a breeding season begins with selection of potential parents the year before crossing. A data file of parent characters is maintained and updated annually. Parents are selected from this data file and from a map of nursery material. A planning sheet with parental characters, especially sex and flowering type, is produced to facilitate the decision of where to place parental varieties in the photoperiod systems. Records on response to photoperiod regimes assist in determining the optimum photoperiod treatment.

It is necessary to update the data base of parental characters annually. New varieties which represent new gene sources are added on a regular basis. Availability of additional data on older varieties may change the ratings for specific traits. A filing routine is used to construct a data library member with a list of new varieties concatenated with the maintained data file. These data are updated and used to construct the new data file.

From the list of parental characters probable mean values for the progeny of bi-parental crosses are computed using an additive model for combining ability. As crosses are made, data can be entered in a data library member, or data can be entered on a microcomputer diskette for later transfer to the data file. On completion of the crossing season a permanent SAS data set is constructed and a report is generated for the office record. A similar procedure is followed with flowering data. The data are entered through SPF, converted into a permanent SAS data set, and a report is generated. Each step requires a separate data library member.

Most of the computer work done in the year of seedling planting involves preparation for transferring seedlings from the greenhouse to the field. After the crossing season has been completed, a list of predicted cross characters for the crosses made is run and saved. This is a fraction of the cross prediction routine which computes all possible bi-parental combinations. Another version of the software identifies crosses with seed in storage to the list of new crosses. Only crosses with more than 300 viable seed are placed in storage. A list of parental characters, germination per unit weight and total viable seed available is made to facilitate planting seed. Information on the fecundity of sugarcane varieties used in crossing is fed back into the parental characters data set.

A file utility routine facilitates listing of crosses for planting. After the seedlings are transplanted to the field, a planting list is entered for the single stool seedlings, with planting order, number planted and survival data.

Seedlings are selected during the second year following crossing. Overwintering data are added to the single stool data file. Ratings for agronomic traits should be collected for each cross represented in single stools.

After single stool selection, first line trial plot plan data are entered by blocks planted. Entering the block, number of rows and plots per row in a filing routine will generate the block and plot numbers so that only cross numbers need to be entered. Data entered once can be easily copied over large segments through SPF editing functions. From block and plot data, a SAS data file will be constructed.

The year of advancement to the 2nd line stage is the third year following crossing. It is in this year of the program, data on individual clones are recorded. Initial data collected are in the form of qualitative ratings. A map of plots is generated by the computer and ratings are entered directly on the map. Samples are taken from clones passing minimum rating standards. Data on juice quality are entered into a data library member. Sucrose calculations are placed in the same SAS data base that holds the 1st line plot plan. Advancements are made based on agronomic rating and juice quality data. Clones advanced to 2nd line are mapped and entered into a new SAS data base by 2nd line block and plot numbers.

In August of the fourth year following crossing, the 1st line ratoon and 2nd line plant cane plots are rated for potential yield. Both sets of data are recorded in the field on computer generated maps. On 1st line maps, only plots advanced to 2nd line are identified. Plots are matched between 1st and 2nd line trials. Based on combined ratings and the previous year's sugar per ton estimate, selections are made and a new map is printed. The stalks in the selected 2nd line trial plots are counted, and promising clones are planted in increase plots. In November, samples are taken for sugar analysis and the data are entered through SPF for processing. Calculated data are stored in a permanent SAS data base along with the plot plans. A summary of all plots in 2nd line is also constructed for use in the fifth year.

The year of variety number assignment is the fifth year following crossing. Maps in which the computer identifies the 2nd line and increase plots to be rated are used to aid the agronomist in locating plots and recording data.

Selections are then made based on current ratings and data from the YEAR4 summary. A new map is printed to identify the plots in which stalks are to be counted. Stalk counts are added to the data file. New culls are made based on the addition of population data. The results of final pre-assignment sucrose data are entered and a new summary is produced with all available information on assignment candidates.

A summary of all available data is sorted by the plot order most convenient for field review. The new assignment names are recorded along with plot information to relate line trial data to later infield and outfield trials. Another sample is collected for fiber and sucrose analysis after assignment. After those results are recorded, a permanent SAS data base containing all line trial information about every new assignment is archived.

SPECIAL REPORTS

The advancement report is a summary of all breeding data collected from crossing through assignment during the year. It begins by generating means of assignment data for the current year's assignments. The new assignment variety means are compared to control standard means. The next part of the report consists of summaries

by crossing series, cross, and female and male parent. Tables for each summary show frequency potted, transferred to the field, surviving transplant, overwintering, selected for 1st line, advanced to 2nd line, and assigned permanent variety numbers.

The software may be run in one step, but it is preferable to divide it into modules for verification at each stage. Separate modules summarize seedlings, 1st line, 2nd line, and assignment data sets. At every stage, each cross is totaled by crossing series. The data are assembled and then printed by a special report writing routine.

Another special report collects data for all post-assignment experimental varieties. All yield data on varieties selected for continued testing are carried forward in the ACTIVE data base. Infield and assignment data from the USDA and LSU programs are added. All data from these tests are also archived in their respective data bases. The annual Active Report for variety advancement is generated by summarizing the active files for each test and variety. Performance of the experimental variety is expressed as a percentage of the check varieties. A test of significance is also included. Data are presented for both the current year and summary across all years. Additional rating data are merged with the active file for the report to the Variety Advancement Committee. Data consists of ratings taken in May and August of the Chacahoula and St. Gabriel infield plots. Also smut, mosaic, and sugarcane borer resistance ratings are included in this report.

The annual office report is not a special section, but is assembled from computer work done in all stages of the breeding program. Documentation was developed to describe standards for variables and the components of the office report. The variables cross, female parent and male parent need standard formats for comparisons among data files. Rules for the input of data help to avoid confusion and alteration of written software. Description of the necessary input and expected output for each routine is included in the documentation. All the routines which generate data for the annual office report are described. The documentation may be easily searched at any time and altered as improvements in computerized data management are implemented.

In closing, modern data management is complex. Computerization requires planning, evaluation, and documentation. The benefits included are rapid and extensive information retrieval. In the Louisiana sugarcane breeding program, we have turned to the computer to facilitate access to all available data. This allows management of additional data that would be logistically impossible by hand. Crossing, planting, and advancement of experimental varieties are made with the fullest knowledge available. More advances lay ahead with the increasing use of microcomputers and the ability to communicate between computers.

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THE GENETIC BEHAVIOR OF RESPONSE TO GLYPHOSATE AS A CHEMICAL RIPENER IN FOUR CROSSES OF SUGARCANE[1/]

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ABSTRACT

The progenies of four crosses of sugarcane (Saccharum interspecific hybrids) were evaluated for changes in juice quality, stalk weight and sucrose per stalk after treatment with the chemical ripener glyphosate (0.448 kg a.e./ha). The differences between treated and untreated plots for each yield component formed a continuous, apparently normal, distribution over a broad range. For individual clones, the heritability estimates (h^2) for sucrose, stalk weight and sucrose/stalk were 0.01, 0.02, and 0.02 respectively. The crosses between parents known to respond to glyphosate produced a lower percentage of responding offspring than crosses between non-responding parents. These results indicate that little or no progress would be made in breeding for response to glyphosate, and suggest that all progeny must be evaluated in advanced stages of variety development. Of the yield components studied, the change in sucrose content in response to glyphosate was negatively associated with the initial sucrose content. No other significant associations were detected.

INTRODUCTION

Increases in the yield of sucrose per hectare have been accomplished in Louisiana by the development and wide acceptance of high sucrose cultivars (3). Today, nearly all sugarcane cultivars grown in Louisiana are considered to have high sucrose. Efforts to further increase the sucrose content of sugarcane cultivars led to the discovery of synthetic chemical ripeners. Glyphosine [N,N-bis(phosphonomethyl) glycine] and glyphosate (N-phosphonomethyl glycine), were made commercially available to farmers in 1975 and 1980, respectively. However, only glyphosate has consistently increased the sucrose content of responding cultivars (11). Further, research has shown a significant treatment by cultivar interaction to the application of both ripeners (1, 5, 6, 8, 11, 13). Martin (9) showed genotypic variation of response to glyphosine for the three yield components: stalk weight, sucrose per ton and sucrose per hectare. Significant differences occurred among 24 experimental cultivars from eight crosses. Further, Martin (10) showed that the differential response of 125 experimental clones to glyphosate was both intraspecific and interspecific in nature. Parameters measured included percent sucrose, refractometer Brix (% soluble solids) and stalk weight.

To determine the feasibility of breeding and selecting for response to the plant growth regulator, glyphosate, a three-year study (1980-1982) was conducted with the following objectives: 1) to determine phenotypic and genotypic correlations for sucrose content, stalk weight and sugar per stalk; 2) to estimate the broad sense heritability and repeatability of response to glyphosate.

MATERIALS AND METHODS

Progenies of four crosses produced at Canal Point, Florida, were used to estimate the heritability and repeatability of response to the synthetic chemical ripener glyphosate. The seed were then sent to the U. S. Sugarcane Field Laboratory at Houma, Louisiana, where they were germinated and established as single stools (2). The crosses were selected based on the known response of parental cultivars to the commercial rates of glyphosate (8). Clones from each cross were selected at random with the only criteria being that all clones have a minimum of four stalks of 1.2 m length or greater. Table 1 lists the four crosses and response classification of parental cultivars.

[1/]Cooperative investigation of the Louisiana Agricultural Experiment Station and USDA-ARS. This research was supported in part by grants from the American Sugar Cane League and Monsanto Agricultural Chemical Corporation.

A randomized block design with a split plot arrangement was planted on October 25, 1979, at the St. Gabriel Branch Station of the Louisiana Agricultural Experiment Station. For each of four blocks, there were 22 experimental clones (main plot) from each of the four crosses. Each block contained a different set of 22 experimental clones. Each experimental clone had two stalks planted in duplicate one row (1.8 m x 1.8 m long) plots (subplots) separated by a 0.3 m pathway. Plots of each parental cultivar were planted in a similar manner in each replication. Glyphosate was applied to one of the sub-plots at the equivalent rate of 0.448 kg acid equivalent (a.e.)/ha using ground equipment and compressed CO_2 as a propellent in 140 liter spray mixture per hectare. The remaining subplot was not treated and served as control. The same procedure was used for each year of the experiment. The application and harvesting dates were October 3 and October 28 in 1980; October 6 and October 29 in 1981; and September 14 and October 4 in 1982. In each year the experiment was harvested in four days.

Only those plots (subplots) having more than five stalks were sampled. Where possible, a ten-stalk sample from each plot was cut even with the ground, topped through the apex, stripped of all leaf material, tied, tagged and weighed. If the plot had between five and ten stalks, all stalks were taken for the sample with the number of stalks recorded. The mean stalk weight was determined using the weight of sample and the number of stalks in the sample. The samples were milled once through a three-roller mill with 500 kg pressure on the top roll. A subsample of the juice was taken for quality analysis in the manner described by Legendre and Henderson (7): Brix by hydrometer, apparent sucrose by polarization and purity as the ratio of apparent sucrose to Brix. Sucrose per stalk was the product of sucrose content and mean stalk weight.

Response of the parental cultivars and experimental clones was calculated by taking the simple difference between the treated and untreated plots. These variables are referred to as response variables and are designated by "D".

Genotypic and phenotypic correlations were determined from the variance and covariance components (4), which were estimated by Henderson's Method III (12). Heritability was calculated using the variance components as shown below:

$$h^2 \text{ (individual)} = 2 * Vc/[Vc + V_{yc} + V_{rc} + V_{yrc} + V_{error}];$$

where V_c = cross variance, V_{yc} = cross x year variance, V_{rc} = cross x replication variance, V_{yrc} = cross x year x replication variance and V_{error} = error variance. Vc represents the covariance among full sibs and has a genetic expectation of one-half additive variance plus one-fourth dominance variance.

RESULTS AND DISCUSSION

The parents of the crosses chosen for this study exhibited a wide range of response to glyphosate. The range included two high responding cultivars CP 65-357 and CP 70-330, two moderate responding cultivars CP 75-360 and CP 66-346 and two nonresponding cultivars CP 67-412 and CP 72-355. Response groups are based on D-sucrose/stalk. Table 1 summarizes the D-sucrose, D-stalk weight, and D-sucrose/stalk data for the parents and their progenies.

Table 1. Summary of parentage, cross number, response grouping, progeny number, parental means and progeny means[1/] for the four crosses as an average over all three years, 1980-1982, inclusive.

Parentage	Cross No.	Response group[2/]	Progeny number	D-Sucrose (percent) Parental mean	D-Sucrose (percent) Progeny mean	D-Stalk weight (kilograms) Parental mean	D-Stalk weight (kilograms) Progeny mean	D-Sucrose/stalk (grams) Parental mean	D-Sucrose/stalk (grams) Progeny mean
CP 65-357 x CP 67-412	1	R x NR	86	1.088, .278	.905	-.017,-.027	-.025	6.54,-1.22	1.9
CP 65-357 x CP 75-360	2	R x MR	86	1.088, .776	.655	-.017,-.021	-.044	6.54, 2.39	-1.0
CP 70-330 x CP 66-346	3	R x MR	84	.891, .617	.473	.043,-.031	-.034	13.50, 2.71	0.3
CP 72-355 x CP 67-412	4	NR x NR	88	.374, .278	.702	-.077,-.027	.019	-1.68,-1.22	4.5

1/Means are the difference between control and treated plots.

2/R = High responder
MR = Moderate responder
NR = Nonresponder

Evidence of the quantitative nature of response to glyphosate can be seen by the occurrence of the experimental clones in a large number of continuously varying classes, with a tendency for the population to fit a normal curve. Figures 1-3 contain the histograms for D-sucrose, D-stalk weight and D-sucrose/stalk, respectively, for the experimental clones of the progeny for cross number 3 over all years of the study.

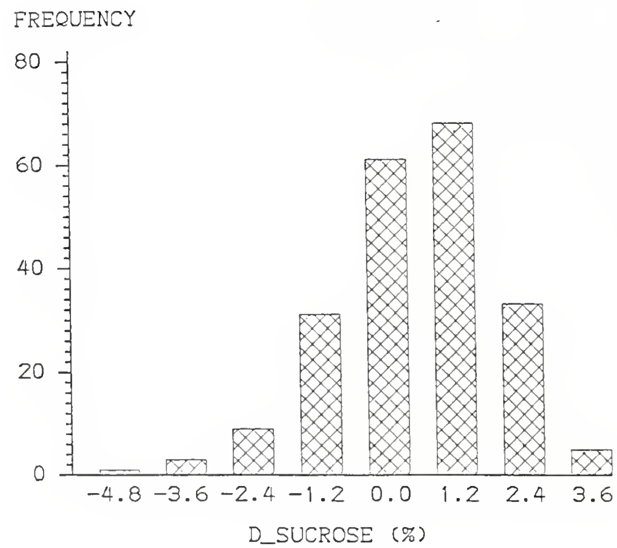

Figure 1. Histogram for D-sucrose for the progeny of cross 3.

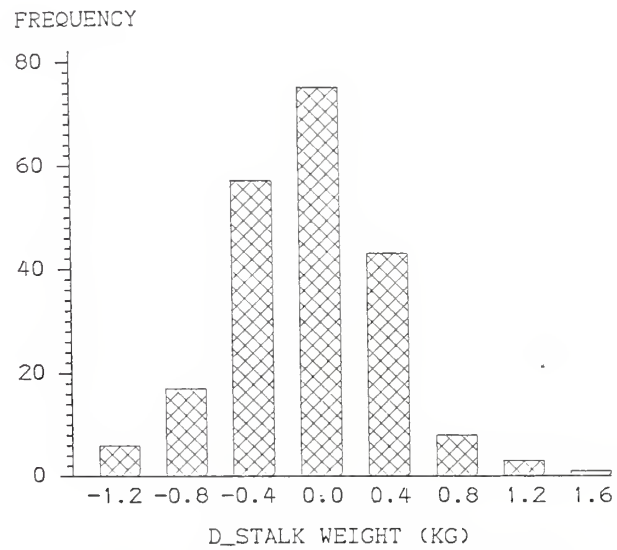

Figure 2. Histogram for D-stalk weight for the progeny of cross 3.

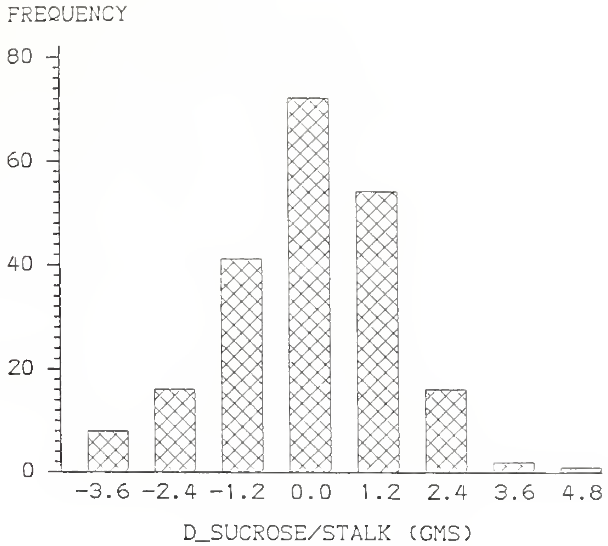

Figure 3. Histogram for D-sucrose/stalk for the progeny of cross 3.

The data indicates that transgressive segregation has occurred. Of the 344 experimental clones from the four crosses, 29 clones had D-sucrose values exceeding the parental values. However, only seven of the 334 experimental clones had stalk weight responses which exceeded the parental values for the parents for the four crosses.

In the evaluation of the genetic behavior of sugarcane in response to glyphosate, emphasis was placed on the response in sucrose/stalk. Here, both sucrose and stalk weight effects are represented. In a combined analysis of the four crosses, six of the 344 experimental clones show D-sucrose/stalk values which exceeded the parental values. Therefore, it is possible to select clones which exhibit both increases in sucrose content and either no change or an increase in stalk weight from large clonal populations.

Heritability estimates for the response variables, D-sucrose, D-stalk weight and D-sucrose/stalk were 0.01, 0.02 and 0.02, respectively. Estimates were calculated for individual clones as an average over all three years. Heritabilities for individual clones were quite small, and selection should be ineffective. Of course, the apparent lack of heritability could be due to the small number of crosses giving inaccurate estimates, or because the genetic component was much smaller than the environmental component.

Falconer (4) defines repeatability as the correlation between repeated measurements on the same individual. In this case, repeatability is estimated from individual response to glyphosate in sucrose, stalk weight and sugar/stalk measured over three years. Estimates of individual repeatability were obtained by calculating average correlation coefficients between the three years. Repeatabilities of 0.094, 0.113 and 0.213 were obtained for the response variables, D-sucrose, D-stalk weight and D-sucrose/stalk, respectively. The values are nonsignificant but indicate some tendency for clones which respond in one year, to respond in subsequent years.

It should be pointed out that 15 clones, or 4.3% of the progeny, exhibited a positive response to glyphosate over all three years. This indicates that it may be possible to choose individuals which exhibit stability for response to glyphosate. Because of the large environmental influence upon response to glyphosate, evaluation of cultivars should begin in later selection stages. Evaluation of cultivars at several locations can increase precision to quantify this response. Effective evaluation could begin at "assignment" or in the "infield" stages of the Louisiana breeding programs (2). Likewise, those clones showing only marginal sucrose content could be advanced to further stages of testing if the cultivars have a consistent positive response to glyphosate.

Breeding for response to glyphosate does not seem feasible due to the low heritability. However, it is possible to select individuals that do respond. The availability of responding and nonresponding cultivars supports this contention. Responding individuals can be identified on the basis of increases in D-sucrose/stalk.

Phenotypic and genotypic correlations were of similar magnitude, suggesting little environmental correlation (Table 2). All were positive indicating a common genetic basis for response to glyphosate in these three traits.

Table 2. Phenotypic and genotypic correlations[1] for the three response variables.

Response variable	D-stalk weight	D-sucrose/stalk
D-sucrose	.15 .16	.63 .40
D-stalk weight		.83 1.12

[1]Upper and lower values represent phenotypic and genetypic correlation coefficients, respectively.

Phenotypic correlations were calculated to determine the association between the response variable D-sucrose and other economic traits, such as sucrose, stalk density, stalk fiber and stalk weight. Early research has indicated that high sucrose clones respond more favorably to synthetic chemical ripeners than low sucrose clones (1, 5, 6, 8, 13). Results were based on observations of commercial variety responses, and not from large unselected clonal populations. The correlation between D-sucrose and sucrose was -0.44**. Low sucrose clones tended to respond more favorably to glyphosate than high sucrose clones. This is advantageous since clones of less than desirable sucrose content can be advanced to later stages of testing in a breeding program. Correlations between D-sucrose and stalk density, stalk fiber and stalk weight were 0.06, 0.07 and 0.05, respectively. All values were nonsignificant, therefore, selecting clones with acceptable stalk density, stalk fiber and stalk weight would be possible when obtaining clones that respond to glyphosate.

The data presented in this paper show that because of the low heritability of response to glyphosate, breeding and subsequent selection would be inefficient. However, it is possible to choose individuals which exhibit stability for response to glyphosate. Sugarcane breeders should begin evaluation of this trait in the later stages of selection, preferably at more than one location to increase precision.

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DEVELOPMENT OF MICROPROCESSOR CONTROLS FOR BAGASSE FIRED FURNACES

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ABSTRACT

Previous studies of automatic controls for bagasse fired furnaces in Louisiana have shown the feasibility of automatic forced draft control systems. The paper presents the results of a study carried out during the 1984 Louisiana sugar crop to further develop the principles of automatic control of bagasse furnaces using a microprocessor-based programmable logic controller. The data obtained validate the concepts of draft control and show how fuel control can be accomplished, thus providing overall boiler control. A brief outline of the further development of the system is also given.

INTRODUCTION

The efficient use of bagasse as the major source of fuel in a sugar factory is of prime economic importance to the industry as a whole and the aim of this project is to define the overall control strategy which would provide optimum fuel usage and combustion efficiency. The results show that the basic philosophy is viable but that further theoretical studies of the response functions are still required.

Boiler Automation Systems

The control of combustion processes in an industrial boiler requires that:

(a) the fuel feed responds to the demand for steam.
(b) the amount of air introduced responds to the fuel flow and is limited to the amount which produces maximum combustion efficiency.

For fossil (oil or gas) fired systems, the major sensory elements of such a system are:

(a) steam pressure monitor
(b) fuel flow monitor
(c) forced draft monitor
(d) gas component monitor

These sensors are used such that a pre-functioned unit sets a value for the fuel to air ratio, so that the combustion process is held very close to optimum. A trim control for this ratio is provided by the flue gas analysis based on the oxygen content i.e., oxygen trim control as shown in Figure 1.

While these commercial units are ideal for fossil fuel, they are too complicated for bagasse furnaces since:

(a) the control of fuel feed is extremely difficult
(b) the quality of the fuel varies considerable with time
(c) the slow combustion rate of bagasse

In fossil fuel boilers, the steam production responds very rapidly to changes in feed supply whereas this is not the case with bagasse furnaces. Under these conditions there is a considerable lag between changes in fuel flow and the response of the heat output.

Natural gas and fuel oil are normally burned with very low excess air, a few percent, whereas with bagasse the range of accepted excess air values is quite large, e.g. 25 to 60%. A large amount of excess air is required to ensure sufficient mixing of the fuel and air, as well as enabling the fuel to be burned in suspension. Also the rate of combustion of the bagasse itself is slow and hence the maximum heat release rate therefore limits the available heat which can be produced.

Under these conditions it is not necessary to provide the cross linking which is standard for gas and oil. Furthermore, since the response of the flue gas to air flow is very rapid, a simple oxygen feedback control system can be utilized to control the forced draft. While the fuel/air ratio control can be eliminated, it is still necessary to retain the sensors so that the fuel feed can respond to the steam demand.

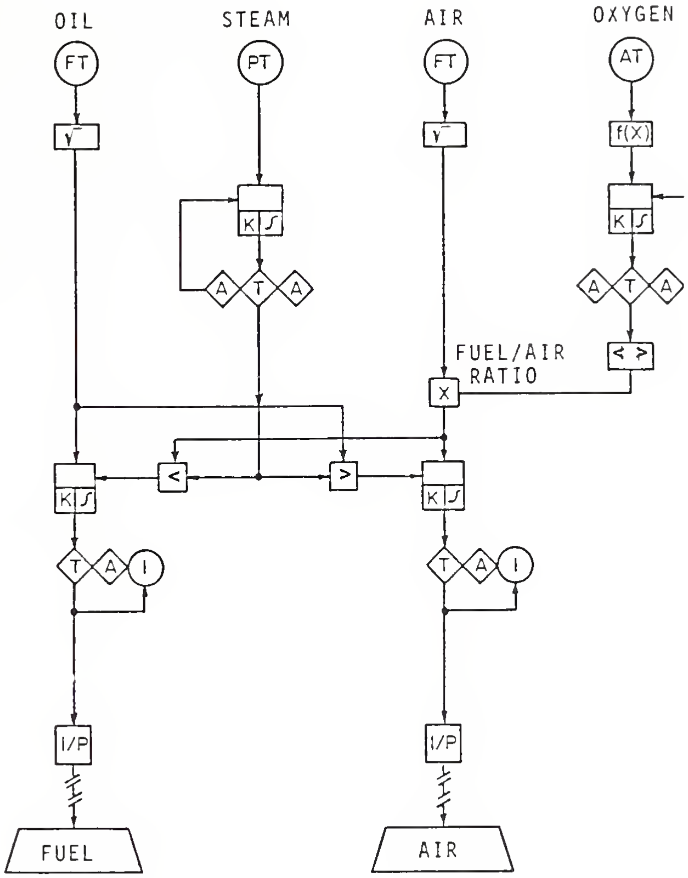

Figure 1. Typical fossil fuel control system.

Bagasse Boiler Description

The boiler on which the experimental system was installed is a 100,000 lb/hr spreader stoker. The undergrate air is preheated and is driven by a 100 hp steam turbine while the overfire air and bagasse spreader air are not heated and are driven by a 100 hp electric motor.

It was not possible to control the air from the electric fan since this has to be maintained at a specific pressure to ensure the bagasse is spread evenly over the furnace. Under these conditions, the undergrate air, which provides 75 to 85% of the total combustion air, is the only air supply which could be controlled.

The fuel is fed on four chutes each of which is fitted with its own chain conveyor. The conveyors are driven by variable speed motors, and the adjustments can be made to the motor speed either manually by dual controls or automatically from an electronic control unit. This unit is a Reliance AC control system which is compatible with normal instrumentation control signals.

The motor speed is adjusted to provide the required fuel flow, with limits being placed on the maximum and minimum speeds corresponding to the practical range of operation of the boiler.

The balance of the furnace draft is maintained by adjusting the speed of the induced draft (exhaust gas) turbine to maintain a constant furnace pressure. The steam pressure of the boiler and the flow rate were also measured. Figure 2 shows the sensing and control elements for the boiler. The temperatures of the forced draft, boiler outlet and exhaust gas were also monitored to provide overall boiler efficiency values.

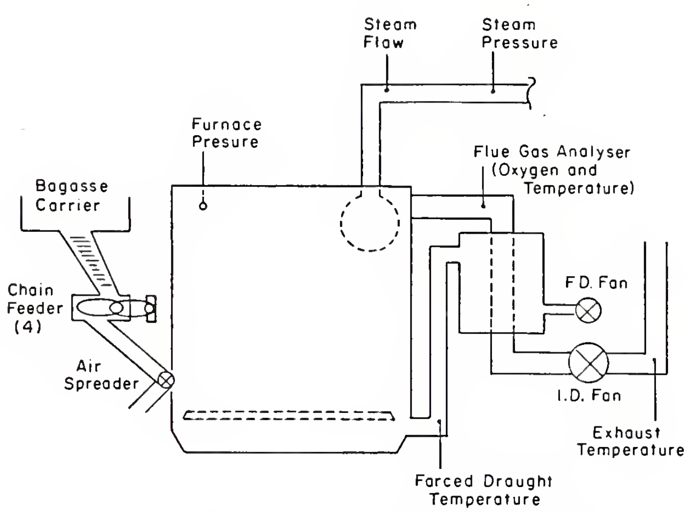

Figure 2. Boiler sensing system.

Microprocessor Control Unit

The control functions as well as data collection were performed by a Reliance Automate 35 which is capable of operating up to eight control loops. The inputs to this unit could be either voltage or current, and hence those sensors whose outputs were pneumatic signals had to be fitted with pneumatic to current convertors. Figure 3 shows the input and output diagram for the Automate 35.

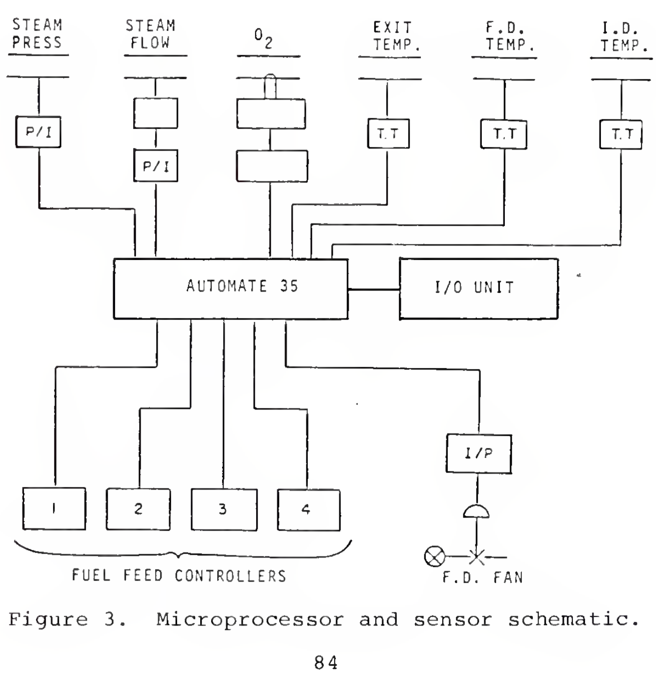

Figure 3. Microprocessor and sensor schematic.

Sensing Equipment Description

The major sensing elements for the control system are:

(a) zirconium oxygen analyzer
(b) orifice plate and differential pressure cell for steam flow
(c) pneumatic pressure cell for steam pressure
(d) thermocouples for temperature

The zirconium oxygen analyzer consists of a cell where ambient air or a gas of known oxygen content is passed over the outer surface of the cell and a gas of unknown oxygen content, in this case the boiler flue gas, flows through the interior of the cell. The difference in oxygen contents across the cell produces a voltage dependent on this difference. The cell is contained in a thermostatically controlled block at a temperature of up to 1500°F. This means that the water which is contained in the flue gas remains as a vapor, and hence the percentage oxygen in the flue gas will be dependent on bagasse moisture.

The temperature at which the cell operates is such that combustible material may burn in the cell and hence has to be removed before the gases reach the zirconium cell. This can produce a significant error in cases where combustible gases constitute a large portion of the gas to be analyzed. However, in the case of a furnace where maximum efficiency is obtained by complete combustion, there is a large amount of excess air, the combustibles content should be zero and hence will not interfere with the oxygen analysis.

Since the oxygen content of the flue gas using the zirconium oxide sensor is moisture dependent, the set point for combustion will therefore vary, depending on the fuel moisture content. This effect has, however, been ignored as the variations in bagasse moisture are relatively small and hence do not seriously affect the oxygen analysis.

The oxygen in the flue gas is determined as a percentage of the total gas volume. When in situ sensors are used, the oxygen is measured in the presence of the water vapor from combustion and the fuel. This is classified as a wet analysis. With remote sensing systems, all the water vapor is condensed and the oxygen content on the dried gas is measured i.e. dry analysis. Figure 4 illustrates the relationship between the oxygen content and excess air for oxygen analyses by both wet and dry techniques.

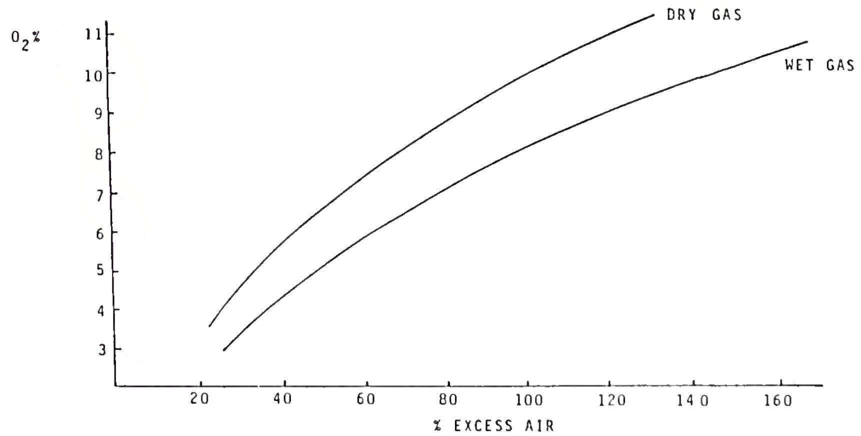

Figure 4. Relationship between oxygen and excess air for wet and dry flue gas.

Design of Control Loops

The two control loops which ensure maximum steam production and peak combustion efficiency are the fuel loop and excess air (forced draft) loop respectively. Due to the sluggishness of the response of the boiler to changes in fuel flow, the steam flow and pressure were combined to give a measure of the total heat output required.

Since the steam pressure is normally at 200 psig and is allowed to fall to 175 psig before natural gas is used as a supplementary fuel, then during periods of rapid demand on steam flow, the drop in pressure which occurs is slow enough to allow sufficient time to provide more steam from bagasse. Thus, when steam demand increases and the pressure drops, the pressure alone could be used to control the fuel feed.

However, when this rapid steam demand is reduced and the pressure has not returned to the normal value, then it is necessary to trim or modify the pressure signal with the flow signal in order to ensure that the boiler is not overloaded with fuel. This suggests that the direction of the rate of change in steam flow is the important parameter in controlling fuel feed.

During initial test analysis of the boiler and feeder system a range of speeds of the feed carriers was determined i.e.:

(a) maximum fuel flow. This corresponds to raising the steam flow rate from 60 to 100% within three minutes while ensuring complete combustion.
(b) minimum fuel flow. The fuel flow required to operate the boiler at 75% flow capacity and 90% full pressure (i.e. 75,000 lb/hr and 180 psig).

The maximum and minimum fuel flow rates and the respective values of feeder speed were used to place limits on the controller output such that the feed rate did not go outside the allowed range.

Similar tests were carried out on the forced draft turbine to limit the range of excess air which could be injected into the furnace and the output of the control loop normalized to provide only the allowable range on the turbine control valve.

RESULTS

During installation of the control system, data were obtained on the boiler while operating under normal conditions in order to compare the effect of the control system when functioning. Figure 5 represents a typical O_2/time variation when the boiler is manually controlled. The range of oxygen contents, 4.2 to 7.4%, corresponds to excess air values of 40 to 90% and is far too large a range to provide efficient combustion.

The ability of the boiler to respond to rapid fluctuations in load demand is critical to efficient operation, and the initial tests on the control system were devised to study the effect of changes in fuel supply on the action of the control system.

The oxygen set point was chosen to be 6%, i.e. about 70% excess air. This is higher than would normally be required, but due to problems associated with tripping out the forced draft turbine at low air flows, this value was chosen as a safe compromise. Figure 6 illustrates the effect of a reduction of 35% in bagasse flow to the boiler. This reduction was accomplished manually by reducing the feeder speed. Before the reduction in fuel supply, the oxygen level was between 5.5-6.5%; but when the fuel was decreased, the oxygen content increased rapidly to above 10%, and at the same time the steam flow fell to about 70% capacity. The controller was unable to reduce the air flow sufficiently to bring the excess air to within accepted limits.

After about 40 minutes, the fuel flow was returned to normal and the excess air controller reduced the air flow and kept it within the required range. This indicates that there are limitations to the range over which the controller will operate.

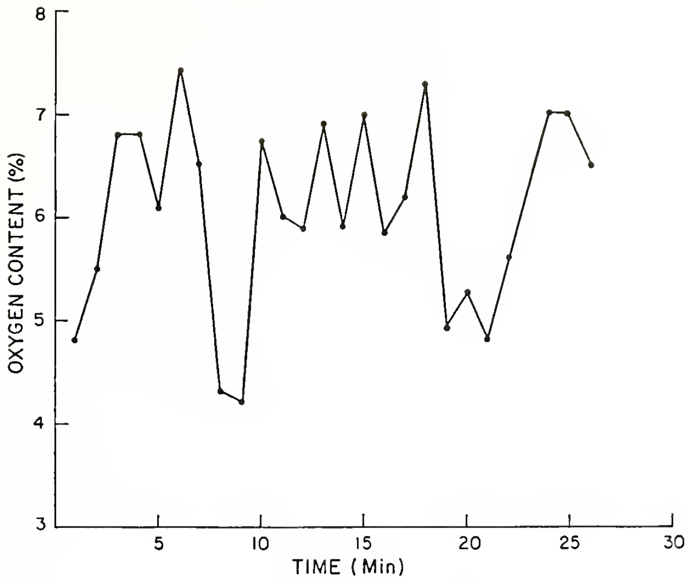

Figure 5. Time variation of oxygen control with manual operation.

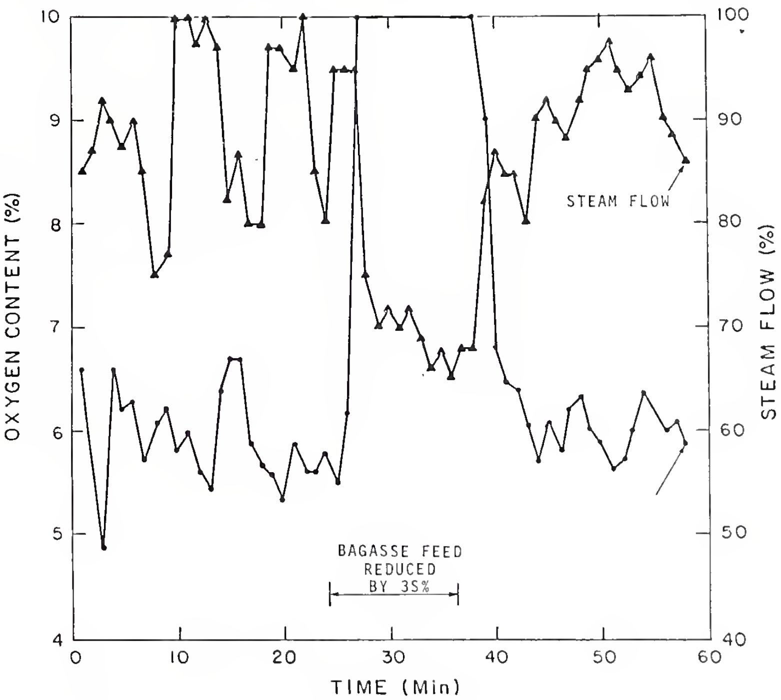

Figure 6. Effect of reducing fuel supply by 35%.

Figure 7 shows a similar occurrence, but in this instance the fuel flow was reduced by 25%. As can be seen, the oxygen content initially increases rapidly, but returns to the accepted levels within five minutes. The steam flow also does not decrease to the same extent as in the previous case. The limitations on the fluctuation of steam output with fuel flow and the response of the forced draft control units are capable of maintaining the boiler at optimum efficiency provided the fuel change does not exceed 25% in a very short time. Although these limitations are based on the specific boiler, the range will be similar for other units and is independent of control equipment.

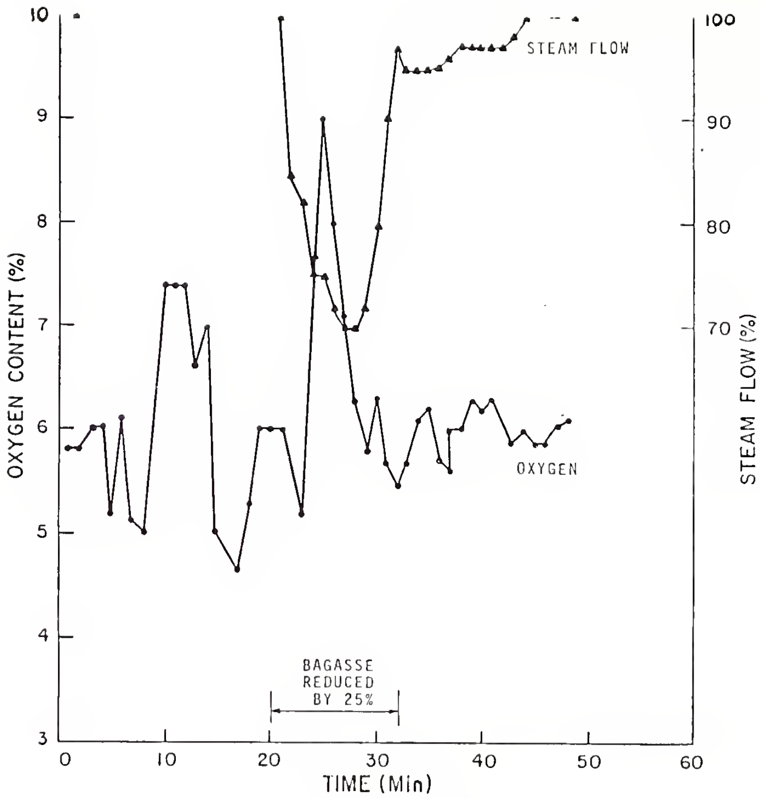

Figure 7. Effect of reducing fuel supply by 25%.

Figure 8 shows the time plots of O_2, steam pressure and steam flow for a one hour period. The oxygen level was set at 6% and in most instances the fluctuation in bagasse supply was so erratic that the control system could not cope with the changes in furnace demand. The extra excess air under these conditions is drawn into the furnace via the feed chutes since these chutes do not remain full with low bagasse supplies. In order to run the boiler with full fuel capacity, it was necessary to make use of the bagasse reclaim system; but since this has a limited capacity, only periods of 30 to 45 minutes could be guaranteed.

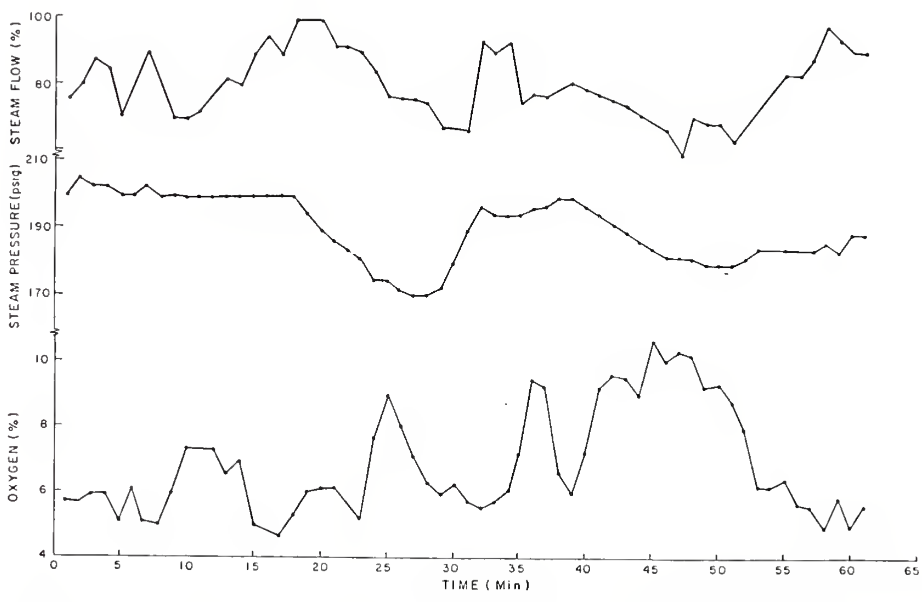

Figure 8. Variations in steam pressure, flow and oxygen content.

Figure 9 shows one such period where the boiler was operated with automatic air flow control but manual fuel feed. The forced draft responds very well to the oxygen in the flue gas and is capable of control throughout the test period. While these data illustrate the ability to control the combustion conditions of the furnace, the rapid cyclic fluctuations in steam flow and hence boiler pressure are not solely due to demand requirements in the factory. The major effect observed is due to the feedback between boilers in the high pressure steam main.

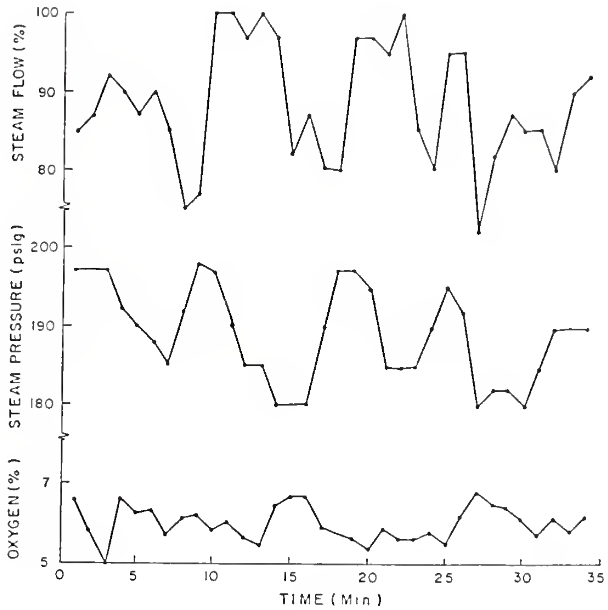

Figure 9. Typical record for automatic control system.

The effective output of any specific boiler will be determined by the pressure in the steam header as well as the factory demand. However, if the output from one boiler changes rapidly, then the other boilers on the line will respond accordingly. The specific relationship between the boilers on the line therefore becomes one of the major problems in ensuring maximum boiler efficiency.

CONCLUSIONS AND FUTURE WORK

The ability of the control system to respond to load changes has been demonstrated within the limits of the existing boiler. The further development of the project will require studies of the following:

(a) more detailed response analysis of the overall system during operation.
(b) correlation analyses to determine the exact relationships between the major parameters, i.e. steam flow and pressure, oxygen, etc.
(c) studies of the effects of fuel quality on the stability of the control loops.
(d) factory energy analyses to study the steam demand fluctuations and thus predict times of peak demand and hence initiate actions to increase steam capacity.
(e) study of furnace combustion kinetics to determine the combustion rate as a function of particle size and hence see if more rapid combustion can be obtained.
(f) boiler simulation studies to determine the control loop response functions and relate these to operating conditions.
(g) extend the study to different boiler systems, particularly those where the fuel feed is controlled to produce a constant fuel loading.
(h) incorporation of drum level and furnace pressure control loops into the microprocessor control system.

It is proposed that the project be operated in two factories during the next crop to provide information concerning the analyses mentioned above as well as providing a useful vehicle for the transfer of new technology.

ACKNOWLEDGMENTS

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1984 ASI MILLING STUDIES

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ABSTRACT

The results of milling tests conducted at eight Louisiana factories during the 1984 crop are presented. The test consisted of collecting and analyzing composite samples of the juices and bagasse leaving each mill in the tandem. The experimental data were used to solve the material balance around each mill in the tandem. Brix curves, moisture percent bagasse plots, calculated extractions, imbibition efficiencies, etc. are presented. The predicted effect of the number of mills, level of imbibition, moisture per cent bagasse, etc. on the extraction is discussed.

INTRODUCTION

Last year, the results of a milling simulation done on a computer were reported. The assumptions used in predicting mill performance were arbitrarily selected. During the 1984 crop, actual data on the performance of several Louisiana mills were collected for analysis.

Typically a run consisted of obtaining samples of the prepared cane, the cush-cush, the prepared cane plus cush-cush, and the bagasse leaving each mill. These cane and bagasse samples were analyzed for pol and moisture using the standard Waring blender bagasse analysis method. The juices from the front roll, the back roll, and the combined juice leaving each mill was collected, together with the remaceration juice being applied to the mill. The juice samples were analyzed for Brix (by refractometer) and pol.

The above samples were typically collected as frequently as possible during a one hour test. Generally, each sample analyzed consisted of about 10 individual grab samples. The data collected permits the front and back roll juice Brix curve to be plotted, while the moisture % bagasse data can be plotted to give a profile of the bagasse moistures through the tandem. The data can be used to calculate the extraction and the imbibition efficiency for each mill in the tandem. To do this, the program described last year was modified to accept the mill juice Brix data and calculate the extraction and the imbibition efficiencies.

In analyzing the 1984 test results, two changes were made to the model. First, the concept of Brix-free water was employed. This concept implies that some of the water in the cane is associated with the fiber in the cane and cannot be separated by milling. In analyzing the data a Brix-free water content equal to 27.5% of the fiber was used. The second modification to the model was to treat cush-cush as a maceration juice steam and allow a mixing efficiency between the cush-cush juice and the juice in the cane (or bagasse) fed to the mill. The 1984 tests consisted of 11 tests at 8 of the state's 21 sugar factories.

RESULTS

Back Roll Juice Brix

Figure 1 shows three of the Brix curves obtained at three of the factories, where the back roll juice Brix has been plotted against the mill number. It will be noted that most of the plots are convex, while one is essentially linear. It may be recalled from last year's paper that convex plots are expected when the imbibition is less than the fiber, while linear plots result from imbibition rates equal to the fiber content. Concave Brix curves would indicate that the imbibition is greater than the fiber. The lack of any concave plots indicates that the level of imbibition is generally less than 100 per cent of the fiber.

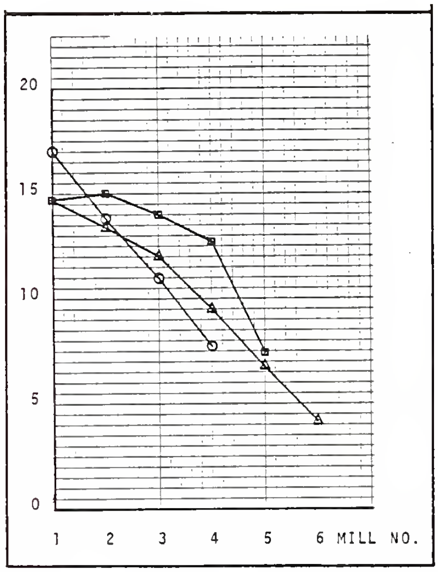

Figure 1. Last roll juice Brix vs mill number for three factories.

Figure 2 plots the normalized average Brix curve obtained by combining all of the data from all 11 mill tests. In normalizing the results, all first mills were treated as zero per cent, all last mills were treated as 100 per cent, while the intermediate mills were considered as a per cent reflecting their location between the first and the last mills. The normalized plot was than obtained by statistically fitting the best curve through the data points. The normalized plots are presented for the case of six mills since this was the most common tandem length tested.

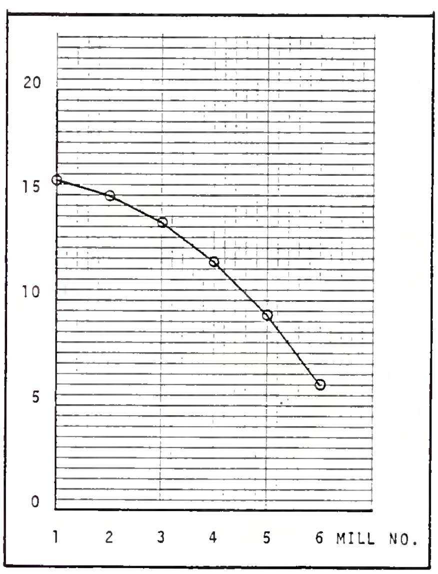

Figure 2. Normalized average Brix curve from 11 mill tests.

Moisture % Bagasse

Figure 3 plots the moisture % bagasse leaving each mill at three of the mills tested. The sharp decline in moisture achieved by the last mill appears to reflect the added attention given to last mill performance.

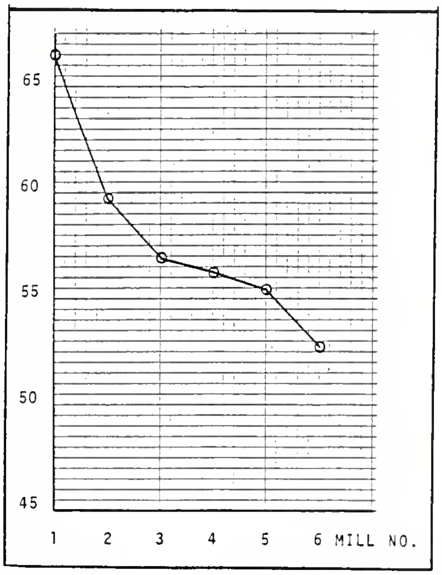

Figure 3. Moisture % bagasse vs mill number.

Figure 4 is a plot of the normalized average moisture % bagasse for all of the mills tested. The general shape of the moisture curve is an exponential decay approaching a bagasse moisture of about 55%. The last mill, however, shows a sharp decline of about 2.5 points over the preceding mill. The shape of the curve indicates that it should be possible to obtain lower bagasse moistures on the mills preceding the last mill.

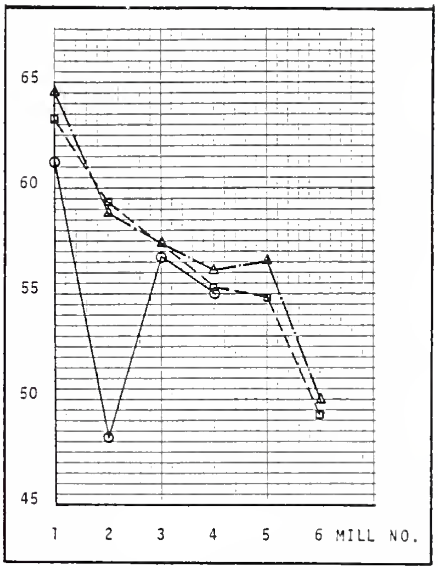

Figure 4. Normalized average moisture % bagasse for all mills tested.

Cumulative Brix Extraction

Figure 5 presents the calculated cumulative Brix extraction achieved through any given mill in the tandem for three of the mills tested. In general, the first mill yields the greatest extraction with each following mill providing additional but declining extraction. The only exception being the last mill which often provides a greater increment in extraction than that of the preceding mill.

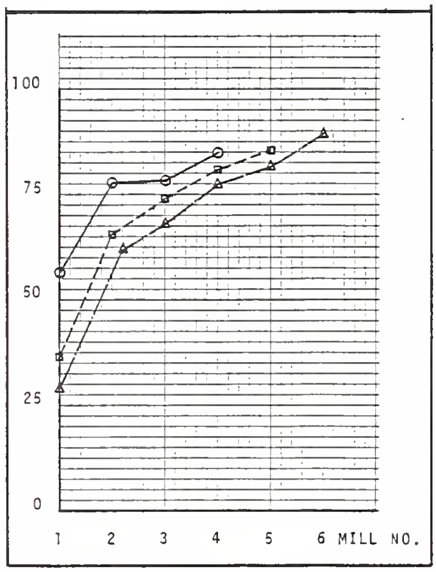

Figure 5. Cumulative Brix extraction vs mill number.

Figure 6 shows the normalized plot using all of the test data.

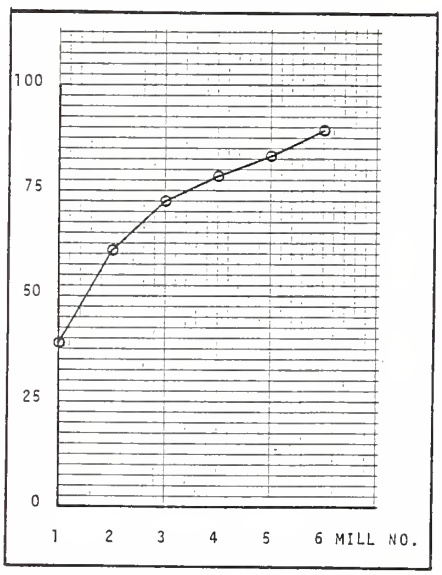

Figure 6. Cumulative extraction vs mill number for all test data.

Individual Mill Brix Extraction

Figure 7 summarizes the extraction achieved by the individual mills in the tandem at three of the mills tested. The individual mill extractions are calculated based on the Brix in the bagasse discharged by the preceding mill. These plots indicate that the individual mill extractions decline slightly through the tandem, except for the last mill which achieves a higher extraction than that of the preceding mill. The apparently depressed first mill extractions are due to the general practice of returning the cush-cush to the first mills.

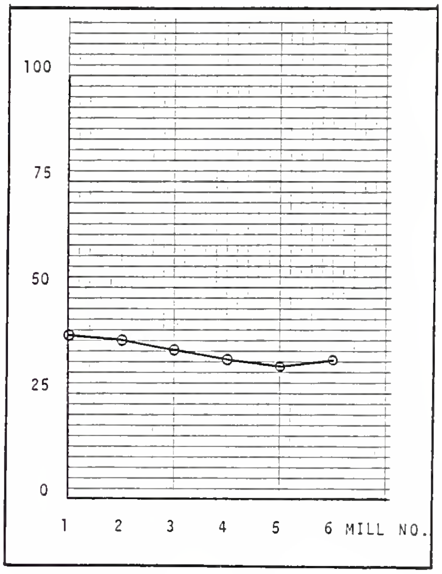

Figure 7. Individual mill extraction vs mill number.

Figure 8 shows the normalized individual mill extraction data for all mills.

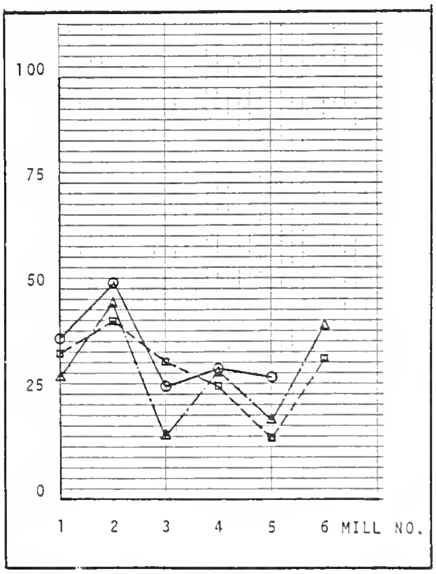

Figure 8. Normalized individual mill extraction data for all mills.

Imbibition Efficiencies

Figure 9 summarizes the calculated imbibition efficiencies at three of the mills tested. The imbibition efficiency is a measure of how well the imbibition liquid mixes with the juice in the bagasse. High imbibition efficiencies yield higher extractions, and vice versa. The imbibition efficiencies are high at the first two mills (necessarily so, since the absence of imbibition results in high calculated imbibition efficiencies), and declines through the tandem. The imbibition efficiencies generally increase at the last mill.

The imbibition efficiency is increased both by higher mill extractions and by better mixing of the remaceration juice with the juice in the bagasse. Based on the data collected, it appears that the imbibition efficiency is most dependent on the degree of squeezing achieved at a mill. An explanation for this may be that it is the squeezing that causes the mixing. In fact, the individual mill imbibition efficiency plots very closely parallel the shape of the individual mill extraction plots.

Figure 10 shows the normalized average individual mill imbibition efficiencies using all of the data obtained.

It would seem that the mill engineer has very little control over imbibition efficiency due to mixing, and that efforts to increase the degree of squeezing achieved at the mill will necessarily increase the imbibition efficiency. In this connection, it would appear that the moisture content of the bagasse leaving each mill is probably the best indication of mill performance.

In this connection, the routine analysis of the bagasse leaving each mill in the tandem for moisture is highly recommended.

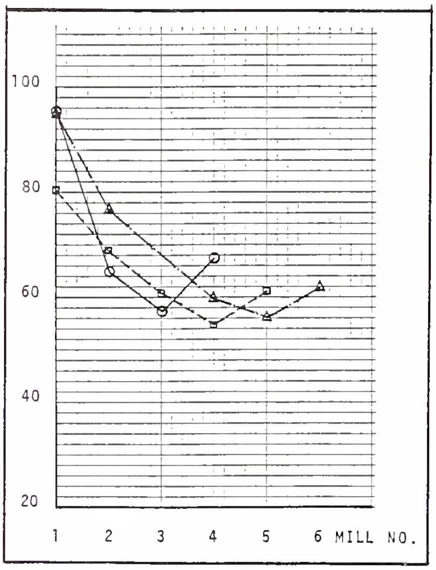

Figure 9. Imbibition efficiency vs mill number.

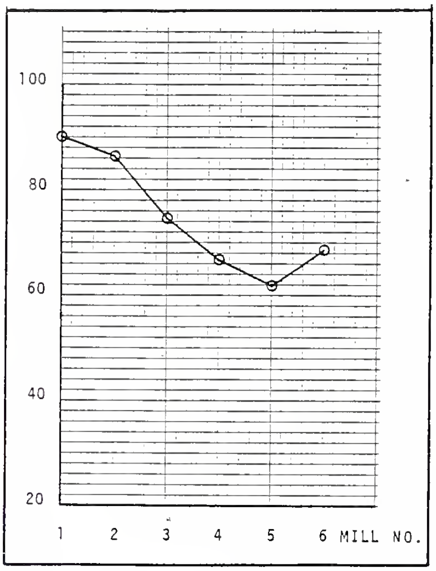

Figure 10. Normalized average individual mill imbibition efficiencies vs mill number.

PREDICTIONS

Based on the average values measured for cane analysis, imbibition % cane, bagasse moistures, imbibition efficiencies, etc. let us predict the effect of some of the important variables on mill performance.

The predictions assume a fiber content in the cane of 12.5%, an imbibition % cane of 10%, the use of a compound maceration juice scheme, and the normalized average values for bagasse moistures and imbibition efficiencies unless stated otherwise. It is also assumed that a quantity of cane wash water equal to 3% of the cane weight enters the mill with the cane. The assumptions are summarized in Table 1.

Table 1. Assumptions for predictions.

Fiber % cane	12.5
Imbibition % cane (on last mill)	10.0
(with cane)	3.0
Imbibition scheme	compound
Bagasse moistures	normalized
Imbibition efficiencies	normalized

Level of Imbibition

Figure 11 shows how the predicted extraction of a 5-mill tandem will increase as the quantity of imbibition water applied is increased.

Without any imbibition, the extraction expected would be only 80.84. At 10% imbibition, the extraction would increase to 89.34, while at an imbibition level of 20% on cane, the extraction would be 93.87. At the very high imbibition level of 50% on cane, the predicted extraction increases to 97.76. It should be noted that in South Africa where the industry average imbibition % cane is over 50% on cane, extractions of 97 to 98 are routinely achieved.

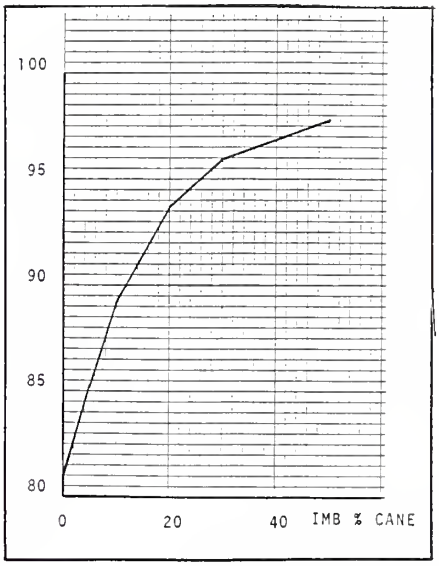

Figure 11. Moisture percent bagasse vs imbibition.

Brix Curves

Figure 12 plots the predicted mill juice Brixes for a 5-mill tandem at various levels of imbibition (0 to 50% on cane). Note that the Brix curves are convex at low levels of imbibition, and concave at the higher levels of imbibition. For imbibition levels equal to the fiber content in the cane, the Brix curve becomes a straight line.

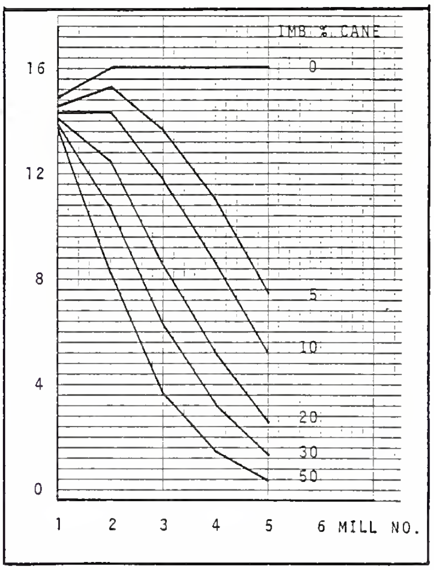

Figure 12. Mill juice Brix vs mill number for various levels of imbibition.

Number of Mills

The extraction achieved by a milling tandem would be expected to increase as the number of mills in the tandem increases. Figure 13 shows how the extraction increases with the number of mills. The extractions predicted assume an imbibition % cane of 10%, and a fiber content in the cane of 12.5%:

For 3 mills the predicted extraction is 81.82.
For 4 mills it is 86.75.
For 5 mills it is 89.34.
While for 6 mills it is 90.85.

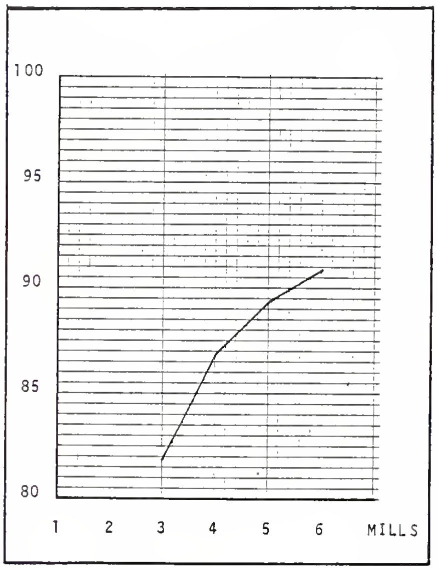

Figure 13. Predicted extraction vs number of mills in the tandem.

Moisture % Bagasse

The moisture % bagasse in the bagasse leaving a mill indicates the degree of squeezing achieved by the mill.

Figure 14 shows the predicted cumulative extraction expected by a 5-mill tandem for typical moistures in bagasse (the center plot), and for bagasse moistures 2% lower out of each mill (the top curve), and for bagasse moistures 2% higher than average out of each mill (the bottom plot). The average bagasse moisture profile yielded a tandem extraction of 89.35. Increasing the bagasse moistures by 2% lowers the final extraction to 87.34, while lowering the bagasse moistures by 2% increases the extraction to 91.05%. In other words, the reduction in the moisture % bagasse by 1% for each mill in the tandem will result in an increase in the extraction of the tandem of 1%.

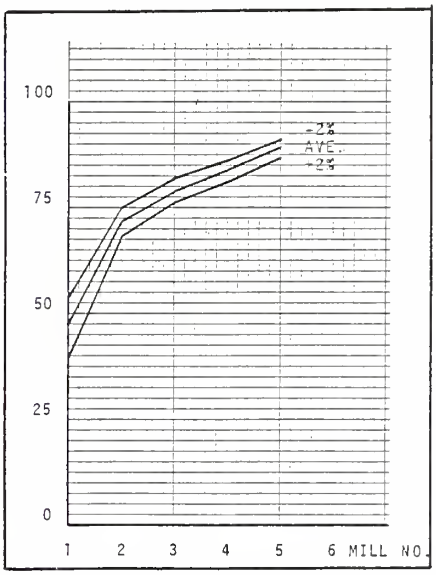

Figure 14. Cumulative extraction vs mill number vary moisture % bagasse by 2%.

SUMMARY

Two of the findings whose implementation will greatly improve mill extraction are:

1) Apply much more imbibition water than is the practice in either Louisiana or Florida.

2) Pay greater attention to bagasse moisture leaving all of the mills in the tandem - not just the bagasse moisture out of the <u>last</u> mill.

APPENDIX

DATA AND RESULTS

Table 2. Back roll juice Brix.

Mill Code	Mill Number 1	2	3	4	5	6	7	8
P-1	17.0	13.8	11.0	7.7				
I-2	14.7	15.0	14.0	12.7	7.4			
Q-1	15.4	14.8	11.9	8.7	6.4			
F-1	13.1	13.5	13.0	12.9	12.3	10.0	9.4	4.75
O-1	17.6	15.8	13.6	13.1	-	6.7		
O-2	17.5	15.5	14.5	12.5	-	6.3		
I-1	16.5	15.8	14.3	13.5	9.2	5.3		
G-1	16.2	17.0	14.4	11.3	8.6	5.4		
N-1	14.6	13.4	12.0	9.5	6.8	4.2		
R-1	14.8	14.8	13.5	12.8	9.4	6.3		

Table 3. Moisture % bagasse.

Mill Code	Mill Number 1	2	3	4	5	6	7	8
P-1	61.22	48.20	56.74	55.00				
I-2	67.09	59.77	56.62	52.90	55.26			
Q-1	64.21	52.80	52.82	50.32	51.74			
F-1	73.20	66.60	65.80	61.40	60.60	60.00	56.60	49.60
O-1	60.19	57.99	-	52.47	52.26	47.34		
O-2	63.32	59.42	-	55.28	54.82	49.23		
I-1	66.49	60.66	56.89	53.58	56.14	57.02		
G-1	67.01	57.58	57.74	59.57	58.88	55.50		
N-1	64.45	58.90	57.36	56.16	56.55	50.00		
R-1	69.99	61.07	57.90	56.53	58.28	54.98		

Table 4. Cumulative brix extraction.

Mill Code	Mill Number 1	2	3	4	5	6	7	8
P-1	56.51	77.71	77.94	85.04				
I-2	36.54	65.17	74.14	81.00	85.40			
Q-1	38.35	69.87	77.90	84.76	89.17			
F-1	5.04	33.02	49.73	62.07	69.69	74.75	81.17	90.63
O-1	60.66	69.16	75.42	81.00	84.66	89.83		
O-2	45.39	63.29	68.97	76.35	81.73	88.29		
I-1	34.50	62.32	74.68	81.46	84.17	89.44		
G-1	36.10	67.27	73.93	79.61	84.36	90.24		
N-1	49.06	70.61	78.26	83.99	87.98	92.14		
R-1	28.98	62.12	67.82	77.53	81.76	89.28		

Table 5. Individual mill Brix extraction.

Mill Code	Mill Number 1	2	3	4	5	6	7	8
P-1	56.51	48.75	1.02	32.17				
I-2	36.54	45.11	25.76	26.53	23.16			
Q-1	38.35	51.13	26.66	31.01	28.98			
F-1	5.04	29.47	24.95	24.52	20.13	16.68	25.44	50.21
O-1	60.66	21.61	20.30	22.69	19.27	33.71		
0-2	45.39	32.77	15.46	23.80	22.74	35.89		
I-1	34.50	42.47	32.82	26.79	14.60	33.30		
G-1	36.10	48.78	20.34	21.80	23.32	37.58		
N-1	49.06	42.30	26.03	26.37	24.93	34.56		
R-1	28.98	46.67	15.06	30.18	18.83	41.21		

Table 6. Imbibition efficiency.

Mill Code	Mill Number 1	2	3	4	5	6	7	8
P-1	95.41	64.93	57.32	67.54				
I-2	88.33	106.58	92.28	71.14	77.17			
Q-1	80.21	68.84	60.33	54.76	61.20			
F-1	78.76	79.17	68.30	73.75	64.23	76.45	52.86	76.32
O-1	99.08	85.00	-	65.93	57.65	65.58		
O-2	96.69	76.70	-	59.88	56.03	61.99		
I-1	88.70	95.10	76.57	56.68	48.34	67.00		
G-1	94.32	97.49	89.17	66.70	67.15	67.06		
N-1	93.53	85.64	87.23	63.10	70.52	62.07		
R-1	94.28	95.24	64.41	78.75	75.68	82.00		

Table 7. Supplementary data.

Mill Code	No. of Mills	Brix % cane	Imb % fiber	Extraction fiber = 15%	\$ Lost[1/] per Crop
P-1	4	13.87	90.98	85.04	\$639,000
I-2	5	12.64	57.81	85.40	606,600
Q-1	5	14.18	135.19	89.17	267,300
F-1	8	12.53	114.53	90.63	135,900
O-1	6	14.73	54.27	89.83	207,900
0-2	6	15.18	87.02	88.29	346,500
I-1	6	14.50	122.47	89.44	243,000
G-1	6	14.44	113.90	90.24	171,000
N-1	6	13.21	129.35	92.14	-0-
R-1	6	12.60	83.74	89.28	259,400
Average		13.79	89.93	88.95	\$287,660

[1/]Based on 250,000 ton crop, 20 cents/lb sugar, taking mill N as reference.

DEXTRAN ANALYSIS: A MODIFIED METHOD

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ABSTRACT

Current methods for the analysis of dextran are either tedious and time consuming, or inaccurate. In either case they are not suitable for routine use in the sugar mill laboratory. We have previously reported on a new method for dextran determinations on a variety of sugar samples. Although accurate, this method is also not suitable for routine sugar mill laboratories because of the time and equipment requirements. A modification of this method has been developed which overcomes these disadvantages. The new method can be used for raw sugar analysis in the factory laboratory with minimum equipment addition. Work is being done to extend the procedure to syrups and molasses.

INTRODUCTION

There has been continuous research on methods for analysis of dextran, and numerous approaches from alcohol precipitation to enzyme electrodes (7) have been proposed. The current industrially utilized methods for routine dextran analysis are either time consuming, and/or inaccurate. Reports by R. P. DeStefano and M. S. Irey (4) have established that both the Copper Dextran method of Roberts (8) and the haze method of Keniry et al. (5) are nonspecific for determination of dextran in raw sugar.

We had previously devised an alternative method for dextran determinations on raw sugar samples (3). Although accurate, this method was not suitable for routine use in sugar mill laboratories because of the length of the procedure and the equipment requirements. A modification of this method has been developed which overcomes these disadvantages. Our earlier method (ASI 1) separates polysaccharides (including dextran) from the sugars using an ultrafiltration process. Sugar solutions were centrifuged in "Centricon" tubes, which contained an ultrafiltration membrane of 10,000 molecular weight cutoff. They separated the high molecular weight polymers from simple sugars and then the amount of dextran present in the polymer fraction was quantitated with a dextranase based assay. The major disadvantages with this method were that it required a high speed centrifuge and had a separation time of four hours.

The modification of the above assay, reported herein, replaces the "Centricon" portion of the procedure with an alcohol precipitation for separation of the polysaccharides from sugars. This simplifies the procedure and reduces the equipment requirements.

MATERIALS AND METHODS

Equipment: Table top centrifuge: A Dynac Centrifuge by Clay Adams, with eight place, 15 ml tubes, horizontal rotor. (Parsippany, NJ).
Water bath: Polytherm bath by Science Electronics Inc. (Dayton, OH).
Spectrophotometer: A Pye Unichem 6-350 Visible Spectrophotometer (Cambridge, England).
Automatic pipets: "Pipetman" from Rainin Instrument Company (Woburn, MA). The sizes used were 100 µl, 1000 µl and 5000 µl.

Materials: Enzymes: The enzymes were purchased from the Sigma Chemical Co., St. Louis, MO. They were α-Amylase, crude from *Aspergillus oryzae*; Dextranase, chromatographically pure from *Penicillium* sp., and α-Glucosidase, partially purified from Bakers yeast.
Chemicals: All other chemicals were of the best commercially available grade. Dextran standards were obtained from Sigma Chemical Co., St. Louis, MO. and from Pharmacia Fine Chemicals, Piscataway, NJ.

Reagents: Absolute ethanol: 200 proof from Midwest Solvent Company of Illinois.
Ethanol 80% (v/v).
α-Glucosidase: A solution containing 34 IU/ml is prepared in 0.1M Potassium Phosphate buffer, pH 6.0.
Dextranase: A stock solution containing 50 IU/ml is prepared in 0.1M Potassium Phosphate buffer, pH 6.0.

Buffer: 1.0M Potassium Phosphate buffer, pH 6.0. 1.0M solutions of monobasic potassium phosphate and dibasic potassium phosphate are prepared. The dibasic solution is slowly added to the monobasic solution while monitoring the pH till the required pH 6.0 is obtained.
Buffer: 0.1M Potassium Phosphate buffer, pH 6.0. This solution is prepared like the 1.0M potassium phosphate buffer except the concentration of the monobasic and dibasic phosphate solutions is 0.1M.
Magnesium sulphate solution: 4.0% (w/v) $MgSO_4 \cdot 7H_2O$.
Nelson-Somogyi Test Reagents (5): Copper Reagent A: 25 gms Na_2CO_3 (anhydrous), 25 gms Rochelle salt, 20 gms $NaHCO_3$ and 200 gms Na_2SO_4 (anhydrous) made up to 1000 ml with distilled water.
Copper Reagent B: 15% (w/v) $CuSO_4 \cdot 5H_2O$ acidified with 1-2 drops of concentrated sulfuric acid per 100 ml.
Arsenomolybdate Reagent: Dissolve 25 gms ammonium molybdate in 450 ml distilled water, then add 21 ml concentrated H_2SO_4. Mix, and then add 3 gms of $Na_2HAsO_4 \cdot 7H_2O$ dissolved in 25 ml H_2O. Incubate at 37°C for 48 hours for the formation of the chromogenic compound. Store in a glass stoppered brown bottle. Care should be taken in handling this reagent.

Sample Preparation: Raw sugar (40 gms) is dissolved in 50 ml of distilled water. To this solution 0.1 gms of α-amylase is added. The beaker is covered with a watch glass and incubated for one hour at 55°C with occasional stirring. The amylase treated sample is made up to 100 ml.

Alcohol Precipitation: Two (2.0) ml of the amylase treated sample are pipetted into a 15 ml glass centrifuge tube and 8 ml of absolute ethanol are then added while mixing. One (1.0) ml of 80% ethanol is used to rinse down any precipitate adhered to the sides of the tube. The tube is centrifuged at 2000 rpm for 10 minutes. The supernate is discarded and the precipitate is resuspended in 10 ml of 80% ethanol and then centrifuged again at 2000 rpm for 10 minutes. The supernate is carefully discarded and the tube inverted on a filter paper to drain all the liquid. The precipitate is then dissolved in water and quantitatively transferred to a 5 ml volumetric flask, the tube is rinsed and the rinses are also transferred to the volumetric flask which is then made to volume with water.

Dextran Analysis - Two 0.8 ml aliquots are withdrawn from the 5.0 ml sample and dispensed into separate 15 ml glass centrifuge tubes. One aliquot is the sample, the other a blank. To each of the tubes is added 0.1 ml. of α-Glucosidase. To the sample tube is added 0.1 ml of dextranase stock solution while 0.1 ml of 0.1M phosphate buffer is added to the blank. Mix. The tubes are "capped" with marbles to minimize evaporation and incubated at 37°C for two hours. At the end of the incubation period, 1.0 ml of the Nelson-Somogyi Reagent (A+B) is added to each tube, mixed and the tubes are then heated for 20 minutes in a boiling water bath. After cooling for 10 minutes, in water, 1.0 ml of arsenomolybdate reagent is added, mixed and the reaction is allowed to go to completion (10 minutes). Ten (10.0) ml of water is added to each of the tubes, mixed and the tubes centrifuged at 15000 rpm for 5 minutes. The absorbance ($A_{500\ nm}$) of the supernate is determined using a 10 mm glass cuvette in a spectrophotometer. The amount of dextran is determined from a standard curve as the difference in absorbance between the sample and the blank. A schematic representation of the complete analysis is shown in Table 1.

Table 1. Modified Method.

Sample preparation
1. Weigh 40 gms sugar and dissolve in 50 ml H_2O.
2. Treat with α-amylase to hydrolyze starch.
3. Make up to a 100 ml volume.

Alcohol precipitation (separation of polysaccharides).
4. To 2 ml diluted sample add 8 ml alcohol. Centrifuge.
5. Wash precipitate with alcohol.
6. Resuspend precipitate in H_2O and make volume up to 5ml.

Dextranase treatment
7. Pipette polysaccharide solution into sample and blank tubes.
8. Treat sample with dextranase and α-Glucosidase to produce glucose from the dextran and treat the blank with α-Glucosidase.

Glucose determination
9. Measure glucose produced by Nelson-Somogyi Method.
10. Determine dextran levels from amount of excess glucose produced using standard curve, and calculate PPM.

Standard Curve Preparation - A valid standard curve can be prepared either using only the dextranase analysis and dextran or by following the complete procedure with dextran, including the precipitation. However, in this case, a modification of the precipitation procedure must be made to duplicate the effects seen with raw sugar solutions. Dextran T2000: Stock Solution 1mg/ml. Glucose Solution: 0.5g/200 ml. Dilute this solution 1 to 40 to give 62.5 µg per ml. Add 0.4 ml of solution per tube which is equivalent to 25 µg glucose, to give a background in order to work in the most sensitive range of the spectrophotometer.

Standard Curve with Dextran, Utilizing Alcohol Precipitation - 0.1 ml of 1M potassium phosphate buffer and 0.1 ml of $MgSO_4$ solution were added to 2 ml of the dextran standard before alcohol precipitation in order to obtain precipitation equivalent to that of raw sugar samples. A typical standard curve obtained with the complete procedure is shown in Figure 1.

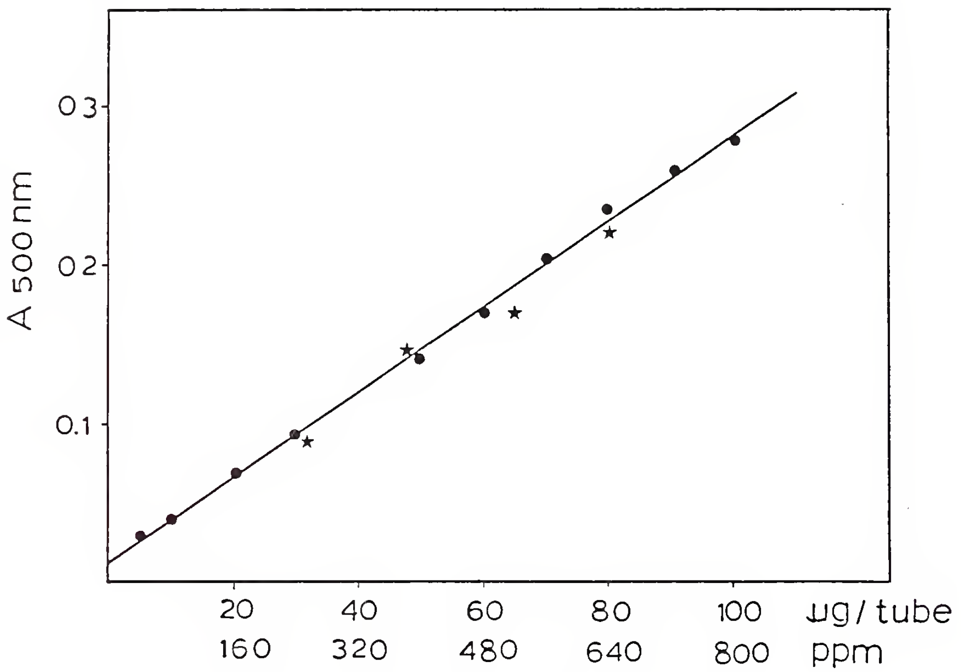

Figure 1. T2000 dextran standard curve produced by (★) alcohol precipitation and (●) dextran assay without precipitation. Values are reported both as µg of dextran/assay and ppm of Brix of dextran in sugar.

RESULTS

Sample Preparation - With this assay it was possible to use 40% sugar solution instead of the 20% solution used in the ASI I procedure. This of course had the affect of increasing the sensitivity of the procedure. The amylase treatment removed the starch present in the sample. Without this pretreatment false high values were obtained due to amyloytic activity in the dextranase (Table 2).

Table 2. Effect of amylase treatment on dextran analysis.

Sample 1/	"Dextran" detected (ppm on sugar)	n2/
No pretreatment	834.6±41.7	3
Amylase added	695.0±35.6	3

1/ Raw sugar sample.

2/ Number of replicates.

Alcohol Precipitation - This is the key step in this procedure (ASI II). The amount of alcohol required for the precipitation of dextran must be at least 50% in final concentration. Up to 80% alcohol in final concentration can be used for precipitation of dextran in sugar (Figure 2). Sixty to 80% alcohol is normally used.

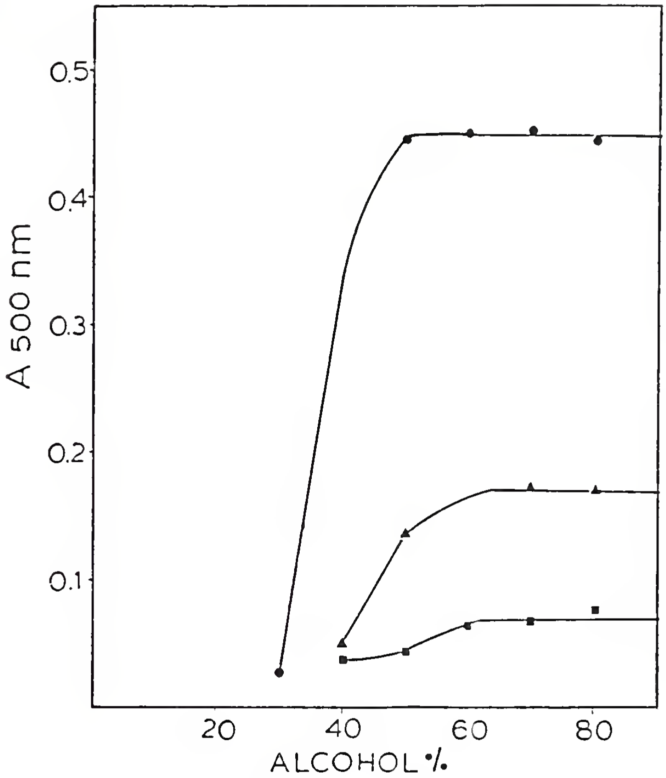

Figure 2. The effect of varying alcohol concentrations on precipitation of dextran. Three samples were tested, they were (●) Dextran T2000 160 μg per tube, (▲) Raw sugar 820 ppm, 52.5 μg dextran per tube, and (■) Raw sugar 338 ppm, 21.5 μg dextran per tube.

The precipitate obtained from the sugar is washed once with 80% ethanol. Traces of sugar left in the sample do not interfere with the analysis. In fact, they are desirable as they bring the absorbance values of the glucose test into the optimum working range of the spectrophotometer when samples with very low dextran levels are analyzed. Glucose is added to the dextran standard for the same reason.

Standard Curve with Dextran, Utilizing Alcohol Precipitation: Raw sugar contains traces of a number of ions, such as Potassium (K_2O), Sulphate (SO_3). Chloride; (Cl), Calcium (CaO), Magnesium (MgO), Silica (SiO_2), Phosphate (P_2O_5), Iron (Fe_2O_3) some of which effect the precipitation of polysaccharides by alcohol (1). Different salts were tested, but the best precipitation of standard dextran was achieved by adding potassium phosphate and magnesium sulfate to the dextran standard solution.

Enzymatic Analysis - Specificity of analysis is due to the use of the enzyme dextranase (E. C. 3.2.1.11) for the α-1, 6 glucan linkages of dextran. Good correlation can be expected with this assay where the dextran in question is not highly branched. This is the case for most dextrans reported associated with sugar process streams (2).

The use of α-Glucosidase with dextranase hydrolyzes dextran present to glucose increasing the sensitivity of the assay. Contamination of α-Glucosidase with other enzyme activities would not affect the results as it is also used in the blank which is subtracted from the sample before calculations for dextran are done.

The glucose provided is measured by the Nelson-Somogyi method and the amount of dextran is determined from the standard curve.

Dextran T2000 was used as a standard in order to be consistent with existing assay procedures. Other dextran standards gave equivalent results.

Analytical Reliability and Sensitivity - This method is an improvement on our previous procedure because of increased reliability with very small size dextrans. The use of alcohol precipitation has made the procedure as sensitive to dextrans of varying molecular weight as any previously reported procedure (Figure 3).

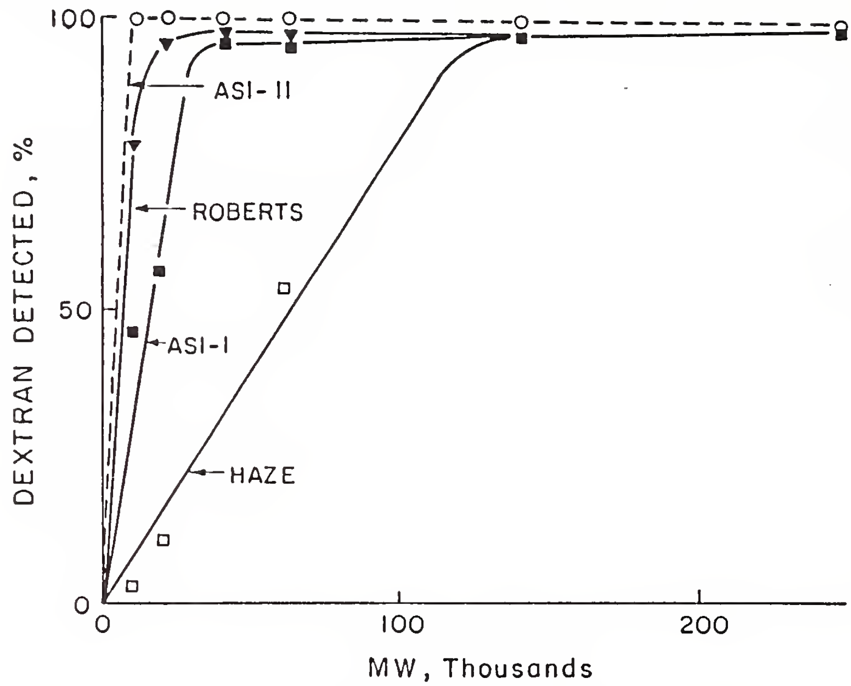

Figure 3. The effect of dextran molecular weight on the detection limits of various dextran assay procedures. The methods were, (□) Haze Method, (▼) Roberts procedure as recommended for standards, (■) ASI-I, our earlier method with "Centricons" and dextranase analysis and (O) ASI-II, the procedure detailed in this report.

Unlike the Roberts (8) and the haze (5) methods which are not specific for dextran (4), this method, because of the dextranase specificity, detected only α-1,6 glucose linkages, such as those found in *Leuconostoc* dextrans. The procedure is reliable and reproducible. Recovery of dextran added to raw sugar is between 94.7% and 98.4% (Table 3).

Table 3. Dextran recovery.

Sugar Sample	Dextran T2000 Added (μgms)	Added Dextran Detected (μgms)	Recovery %
1	32	31	96.8
2	64	63	98.4
3	141	133.5	94.7

The procedure measured accurately any sugar sample containing greater than 40 ppm dextran on solids.

DISCUSSION

This method, like others, requires the preliminary separation of polysaccharides from simple sugars prior to analysis. As with the haze and Roberts procedures, an alcohol precipitation was used as the basis for this separation. The precipitate is separated from the sugar solution by a simple, low-speed centrifugation. Extensive washing is not required, and in fact would be deleterious. Because alcohol precipitation is used, dextran of sizes at least as small as 10,000 daltons can be measured.

Sample preparation requires treatment of the initial sugar solution with amylase to remove starch. Starch is one of the few compounds that will give a false reading as the enzyme used has some activity toward α-1,4 linkages. Specificity of the assay is provided by using a combination of dextranase and α-Glucosidase. This has the result of breaking any α-1,6 glucose linkages present and in the case of dextran converting them to glucose. The glucose produced is then quantitated by the Nelson-Somogyi arsenomolybdate method.

It was found that the average analyst can routinely process up to 30 samples in a day, with this method. The analysis requires three hours of incubation, leaving the analyst free for other duties during this period. The equipment required is minimal, a simple centrifuge, incubator and spectrophotometer. This method appears to be adaptable to use in the raw sugar factory laboratory. It is hoped a report on the utilization of this method under factory test conditions can be available in the near future.

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THE GLUCOSE ELECTRODE AND ITS USE IN THE SUGAR MILL LABORATORY

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INTRODUCTION

In the late 1960's, a new concept in electrodes emerged - the enzyme electrode. This device mated the standard electrochemical electrode with the high specificity of enzymatic catalysis. A number of instruments have since evolved for specific analysis based on enzyme electrodes. The enzyme electrode works by coupling an enzymatic reaction with a second enzyme reaction which produces electrons which are then detected by an electrochemical electrode. For sugar analysis, this usually involves coupling the reaction of glucose oxidase to a peroxidase and then to an electrochemical electrode.

Although commercial sugar analyzers based on this principle have been on the market for several years, they have found primary application in the clinical laboratory. One such instrument is produced by the Yellow Springs Instrument Company (Yellow Springs, Ohio). This instrument uses an immobilized glucose oxidase horseradish peroxidase electrode to measure glucose concentrations in solution. There is also available for the instrument a probe which adds an invertase to this enzyme detector such that sucrose can be directly measured in solutions which are free of glucose.

During the 1984 crop, a study of this instrument was undertaken to determine its potential for use in the sugar factory laboratory. This research paralleled a similar program undertaken in Australia (1). The details of our findings and recommendations as to the suitability of the instrument in the raw sugar manufacture are given in this report.

METHODS

Instrumentation - A YSI Model 27 Industrial Analyzer equipped with a glucose probe was used for all analyses. A 25 µl injection volume of sample was used and the glucose levels were read directly.

Sample Preparation - All samples (juice, molasses, sugar) were diluted with a buffer containing 10 grams per liter Na_2HPO_4 and 30 grams per liter NaH_2PO_4 until they contained approximately 0.5% sugar. Then 25 µl were withdrawn for glucose analysis. To a three ml sample, 0.1 ml of a solution containing 20 mgms/ml of invertase was added. The sample was incubated for 20 minutes at 55°C and then a second aliquot of 25 µl was injected into the analyzer and the glucose content again determined. Sucrose levels were determined by difference. The turn around time between injections was two minutes. This allowed for a one minute flushing of the reaction cell between samples. For multisamples the baseline glucose analysis was done on 10 samples, then they were set up for inversion, then followed this by baseline analysis on the next set of ten and then return to the first inverted samples. With this procedure one person could effectively analyze between 30 and 35 samples an hour for glucose and sucrose concentrations.

Sampling - Samples of factory juices were obtained on-site, at the St. Gabriel Experiment Station, at a Louisiana raw factory and at the Audubon Sugar Institute.

Standard Analysis - Standard pol analyses were performed on all samples using a Rudolph Autopol Instrument. Reducing sugars were determined on molasses by the Lane-Eynon procedure. Brix determinations were by refractometer.

RESULTS

Rate of Inversion - The determination of sucrose requires inversion and then measurement of the increase in glucose concentration when a glucose probe is used. It was found that under the previously described conditions inversion was complete in less than five minutes (Figure 1). This routine procedure for analyzing multisamples allowed a 20 minute interval between the initial glucose measurement and the inverted sample measurement ensuring adequate time for inversion. Inversion time was not a significant problem as the shortest turnaround time that could be achieved for a single sample between the initial sample injection and the second injection was three minutes. This period should be adequate for the complete inversion of any sample.

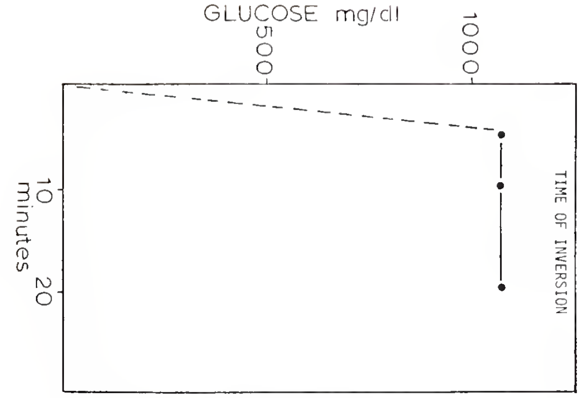

Figure 1. The degree of inversion of a 1.0% sugar solution is shown as a function of time of incubation at 55° C, after the addition of 2 mg of invertase to a 3 ml sample.

<u>Crusher Juice Analysis</u> - A series of analyses of different crusher juices from a series of experimental cane varieties were run in tandem with routine pol analyses at LSU's St. Gabriel Experiment Station. The comparison of pol value versus sucrose concentration as determined by YSI is shown in Figure 2. The line shown is a 45° correspondence line. The correlation coefficient was 0.91.

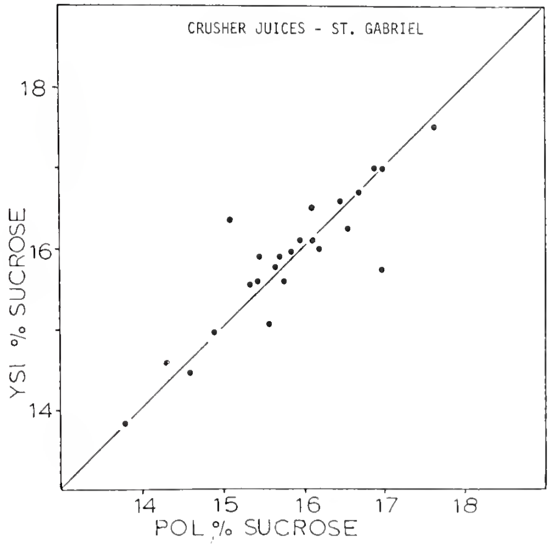

Figure 2. A plot of YSI % sucrose versus pol % sucrose on crusher juices obtained from experimental cane samples taken at the LSU St. Gabriel Experiment Station. The line indicates the 100% correspondence line.

Process Juice Samples - Factory samples were monitored at the Audubon Sugar Institute and standard analyses were compared with the YSI analysis. The results are shown in Table 1. A series of molasses samples collected as part of the ASI molasses analysis program from a number of the Louisiana factories were analyzed by YSI as well as Lane-Eynon. A comparison of representative samples is shown in Table 2. There was an average difference of 1.8 ± 1.6% between the Lane-Eynon and the YSI values.

Table 1. Comparison of analysis-mill juices and syrups.

	Audubon Samples % Sucrose		
Sample	YSI	Pol	% Glucose
Crusher Juice	15.84	15.91	0.23
Mixed Juice	13.09	13.01	0.20
Last Mill Juice	3.97	4.27	0.09
Clarified Juice	12.21	12.11	0.18
Syrup	51.49	52.44	0.90

Table 2. Molasses analysis.

Mill	Sample	% Sucrose YSI	%Sucrose(Lane-Eynon)
G	1	31.93	33.13
	2	32.62	33.38
I	1	25.60	33.12
	2	31.08	32.74
J	1	34.46	34.92
	2	33.86	34.78
O	1	34.54	36.49
	2	34.65	37.59
Q	1	33.47	34.05
	2	33.62	34.71
R	1	31.03	33.63
	2	32.02	33.72
S	1	31.38	32.57
	2	31.13	32.22

Difference in means (Lane-Eynon - YSI) = 1.84 ± 1.65.

Sugar Analysis - Raw sugar samples from different factories were analyzed for % pol and % sucrose by YSI and the values compared. Representative values are shown in Table 3. One sample was also analyzed six times to obtain a value for the precision of analysis. There was an 0.9% average difference between pol and YSI values.

Table 3. Raw sugar analysis.

Sample	Pol	YSI % Sucrose
Pure Sucrose #1	99.40	100.85
Pure Sucrose #2	99.39	100.20
Raw Sugar #1	98.12	98.86
Raw Sugar #2	98.44	98.30
Raw Sugar #3	98.48	98.95
Raw Sugar #4	97.92	98.12
Precision of analysis (n=6)	98.1±.12	97.2±.95

DISCUSSION

The YSI glucose analyzer was found to be a convenient analytical tool for analysis of process juices. It has the advantages of not being affected by color, polysaccharides and other non-sugar components. It was relatively simple to operate and required minimum maintenance. Multiple samples could be analyzed at about half the speed one could analyze pre-clarified juices using an automatic polarimeter with a flow through cell. A comparison of % pol with YSI % sucrose on a number of crusher juice samples showed that the values for sucrose in crusher juices were slightly higher than those determined as % pol. The correlation with pol analyses was only 0.91, however it must be pointed out that pol and the YSI measure different parameters. Pol is liable to be affected by the presence of numerous other components which might be present in cane juice whereas the YSI instrument sees only glucose. Certainly other sugars produce responses from this instrument i.e. raffinose, melibiose and kestose but for all practical purposes these are not a problem to the cane raw factory.

The YSI values for factory juices were comparable to those obtained by pol analysis. In fact, the instrument performed best with these samples. The YSI also produced a value for % invert which could be of use in process control. The % sucrose as determined by YSI for molasses was close to, but consistently lower, by 1-3%, than % sucrose determined by Lane-Eynon titration.

The performance of the instrument was most disappointing on raw sugar samples. Although the pol and YSI values for raw sugar were close, the precision of the YSI analyzer compared to the precision of pol measurement was not good enough for it to be used for any analysis from which payment is determined. According to the manufacturer the instrument is so designed that it is most accurate when there is an appreciable background level of glucose in the test solution. This would account for the lack of precision with high pol samples. A small variation in the initial level of glucose detected could throw the final determination off by 1% or more. Because of the large dilutions required of the initial sample, small errors are greatly magnified.

Although the instrument is not a "universal" tool for the industry it could be a useful adjunct to traditional analytical methods for factory control purposes, not only from its ability to measure sucrose levels but because it will also give a measure of the degree of inversion at any stage in the process. With further experience with the instrument other uses may become obvious (i.e. wash water analysis).

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MEASURING DEXTRAN IN RAW SUGARS - HISTORICAL PERSPECTIVE AND STATE OF THE ART

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ABSTRACT

The historical development of methods for the analysis of dextran in raw sugar is reviewed. The Roberts method and the modified CSR haze method are critically evaluated, and the results of investigations on their specificity are reported. It has been found that a number of organisms other than Leuconostoc are present in large numbers in crusher juice; some of these organisms produce materials detected as dextran by one or both of the analytical methods. It was also found that the materials detected as dextran by the Roberts method responded differently than did purified dextrans or dextran produced by Leuconostoc-inoculated juices to changes in alcohol concentration and to pretreatments with ion exchange resins or dextranase enzyme. Based on these data, it has been concluded that the specificity of both of the dextran methods currently in use for raw sugar settlements is at best questionable.

INTRODUCTION

Though levels of gums or total polysaccharides have been used for many years as a measure of cane quality (19,31), a massive research effort in recent years has demonstrated that a much better indicator of processing quality is a single component of the polysaccharide fraction identified as dextran and produced by the spoilage organism Leuconostoc mesenteroides. An increased emphasis on dextran in the past five years is the direct result of refiner penalties on raw sugars containing what they believe to be excessive levels of dextran (11). Dextran has been implicated in crystal elongation, filtration problems, false polarization, and poor molasses exhaustion, to name a few areas of concern to both millers and refiners. Much research has subsequently shown that dextrans are but a partial contributor to most of these problems, notably the crystal elongation (34) and filterability (14) aspects.

Unfortunately dextran is unusually difficult to analyze because of the relatively low part per million levels usually present and because of its physical characteristics. It is not just one molecule but a series of similar molecules with a wide range of molecular weights, typically with a bimodal or even trimodal molecular weight distribution (4,37). To complicate matters further, L. mesenteroides is just one of many organisms in the juice producing extracellular products that may be carried over into the sugar in varying degrees. In addition, polymeric materials from the soil and from the plant itself also may find their way into the process.

Several alternative methods for dextran analysis have been proposed over the years, each with its own advantages and disadvantages. Among these are the enzyme-dialysis method (29), the viscometric method (10), a very elegant enzyme electrode method (30), an immunological method (9), and the original alcohol haze method (28), which has subsequently been modified by others to increase its specificity. Of these, only the last-mentioned procedure, the haze procedure, has until recently been practical for a routine testing situation. While the results of the haze procedure have been successfully correlated with milling difficulties (21,39), the method suffers from the fact that the haze formed is sensitive to the molecular weight of the dextran present (22). In addition, the identity of the haze-forming material is not completely clear. Reports of positive haze tests on juice from fresh cane (17), of non-glucose polysaccharides isolated from the haze precipitate (13), and of haze not removed by dextran-specific enzymes (36) are troubling.

The Roberts or copper reduction procedure for dextran (33) has been introduced largely to address these shortcomings. This method involves a nonspecific precipitation of high molecular weight materials with a high (80%) concentration of alcohol. After being washed free of simple sugars, the precipitate is redissolved and treated with alkaline copper sulfate (15) to selectively reprecipitate the dextran fraction. The well-known phenol and concentrated sulfuric acid reagent (7) is then used to actually quantitate the dextran. The obvious advantages of this method

are (1) the absence of the preliminary cleanups with ion exchange resins and the amylase enzyme necessary in the haze procedure to eliminate interferences from salts and starch, (2) the lack of dependence on molecular weight deriving from the fact that all dextrans are hydrolyzed to glucose by sulfuric acid, and (3) the specificity of the procedure for dextrans. Disadvantages are the very corrosive nature of the reagents used and the extreme sensitivity of the phenol-sulfuric acid color reaction to all carbohydrate materials. While the Roberts method has been shown to be free of interference from both starch and indigenous sugarcane polysaccharide (ISP) (18), no other potential interferences were explicitly dealt with. Our work is an attempt to address this problem and further define the degree of specificity exhibited by the Roberts dextran analysis.

MATERIALS AND METHODS

Dextran analyses

The haze method used was that of Chou and Wnukowski (3). The Roberts method (33) was followed exactly when analyzing sugars, but was modified when applied to juices or to microorganism broth cultures. In the latter cases, the sample was heated to boiling, allowed to cool, then passed through coarse filter paper to remove suspended solids. This was followed by addition of 3 ml of 10% (w/v) trichloracetic acid, 40 ml of absolute ethanol, and 0.3-0.4g of acid-washed filteraid. This was mixed thoroughly and then filtered through a 15 ml coarse sintered glass filter. The remainder of the procedure was identical to that used for sugars.

Phenol-sulfuric acid color reactions producing absorbances greater than 0.7 were repeated using smaller aliquots of sample, with the volume difference made up with distilled water.

Ion exchange resin pretreatment

Sugars were deionized by stirring 250 ml of 8.0° Bx raw sugar solution with 4.3g each of Amberlite IR-120 and Amberlite IR-45 resins (Rohm and Haas) for 30 min. In the case of juices and microorganism cultures, 50 ml of sample was stirred with 4.3g each of the resins. The resins were thoroughly washed with distilled water, briefly rinsed with acetone, and air dried prior to use.

Dextranase pretreatment

A 3000 ppm (v/v) dextranase stock situation was made by diluting 3 ml of *Chaetomium gracile* dextranase (450,000 DU/g, Miles Biochemicals) to 1000 ml with distilled water. Two ml of the stock solution were mixed with 58 ml of sample solution to yield a working concentration of 100 ppm (v/v) in all cases. The samples with enzyme added were incubated for 1 hr at 50°C to effect hydrolysis.

Isolation, culture, and enumeration of juice microorganisms

All bacterial isolates used in this study were obtained from crusher juice. Isolations to obtain *Leuconostoc* sp. were made by making 100-fold serial dilutions of crusher juice in distilled water and plating 0.05 ml on a modification of a selective medium developed for *L. mesenteroides* (25). The medium (SA) consisted of 23.5g Difco Bacto-plate count agar (5g tryptone, 2.5g yeast extract, 1g dextrose, 15g agar), 100g raw sugar, and 1000 ml distilled water. After autoclaving and just prior to use, 5.0 ml of a sterile 1% sodium azide solution were added to give a final concentration of 0.005%. Plates were incubated for 48 hrs at 30°C. Isolations of non-*Leuconostoc* sp. were performed as above with the exception that Difco nutrient agar (NA) was used instead of SA. Separation and identification of isolates into *Leuconostoc* and non-*Leuconostoc* groups were based on growth or no growth on SA and NA and on colony morphology (16,25). *L. mesenteroides* produces characteristic slimy colonies on SA while growth of other organisms is absent or very much reduced. On NA, *L. mesenteroides* grows very poorly and requires incubation periods of up to 7 days for colony formation while non-*Leuconostoc* isolates grow well and are usually visible after 24 hours.

Colony counts were made after 48 hrs on the plates obtained from the serial dilutions. Population levels of *L. mesenteroides* were determined from SA plates,

while counts of non-Leuconostoc bacteria were made from NA plates. Several different colony types were found most often on NA plates; these were separated into groups based solely on colony morphology and counted to estimate the frequency of occurence of each colony type in crusher juice. Sub-cultures of each colony type were made and used for dextran analysis.

Cultures for dextran analysis

Cultures for dextran analyses were performed in sucrose broth (SB) or in filter-sterilized crusher juice. SB consisted of 10g peptone, 5g yeast extract, 100g sucrose, and 1000 ml distilled water. When crusher juice was used as the culture medium, it was filter-sterilized by passage through an 0.2 µm membrane filter. Cultures were incubated for two to four days at 30°C.

RESULTS AND DISCUSSIONS

Our own interest in this area began with some comparative analyses of a large number of raw sugars by the haze and Roberts methods. Examination of some typical results (Table 1) shows that the dextran values were typically 30-40% higher by the Roberts method than by the haze method (Table 1). In these comparisons, the haze method was standardized against a purified dextran of 40,000 molecular weight with comparatively low haze-forming potential. In actual fact, the native dextran in raw sugars has been shown to be predominately high molecular weight material (4) with a much greater haze-forming potential than the standard T40. It would thus appear that the dextran in raw sugar may often be appreciably overestimated by the haze method because of the dependence of haze on molecular weight. The very large increase of the Roberts dextran over the already inflated haze value led us to believe that the Roberts estimate might very well include something other than just dextran.

Table 1. Comparisons of Roberts and haze dextran results for 12 raw sugars.

	Dextran (ppm)	
Sample No.	Haze1/	Roberts
1	0	150
2	0	313
3	187	288
4	243	350
5	331	690
6	483	850
7	527	894
8	660	997
9	901	1338
10	1105	1542
11	1226	1638
12	1325	1776

1/Haze ppm values calculated using Dextran T40 (Pharmacia) as a standard.

To investigate this possibility, we applied a dextranase enzyme to some solutions of raw sugar just prior to analyzing for dextran by both haze and copper procedures. While the haze response was almost totally eliminated by the enzyme pretreatment, a large percentage of the Roberts dextran was still present (Table 2). It should be noted that a large (approx. 10-fold) excess of enzyme was used based on control experiments in our laboratory with known amounts of purified dextrans. These parallel experiments in which both 4×10^4 and 2×10^6 molecular weight dextrans were treated with enzyme showed that the Roberts copper reagent was not responding to the oligomers or short pieces of dextran left after enzyme digestion of these largely linear dextrans. This was not unexpected, since the main products produced by the enzyme used have been shown (12) to be glucose, isomaltose, and isomaltotriose, all of which are too low in molecular weight to be precipitated by the alcohol.

Table 2. Effects of dextranase pretreatment on Roberts and haze dextran results for raw sugars.

	Haze (MAU)		Roberts (ppm)	
	Before enzyme	After enzyme[1/]	Before enzyme	After enzyme[1/]
Raw sugar #1	475	5	1152	775
Raw sugar #2	673	17	1363	820

[1/]Dextranase pretreatment consisted of incubation with 100 ppm (v/v) Chaetomium gracile enzyme (450,000 DU/g, Miles Biochemicals) at 50°C for 1 hr.

Another explanation considered was that the bacteria present in the juice from which the sugar was made produced dextran with an abnormal structure that was only poorly digested by the enzyme. While the literature indicates that raw sugars from widely separated areas contain dextrans very similar in molecular weight and uniformly high in percentage of α-1,6 linkages (4), it is in fact well known that there are at least four distinct colony types of L. mesenteroides: A, B, D, and F (26). We therefore proceeded to isolate representatives of all four colony types of L. mesenteroides from Florida cane juice and to subject the polysaccharides they produced to the dextranase treatment. It was found that three of the four colony types produced dextrans very susceptible to the action of the enzyme (Table 3), while the type F cultures exhibited some resistance.

Table 3. Effect of Chaetomium gracile dextranase on polysaccharides produced by four different colony types of Leuconostoc mesenteroides from Florida cane juice.

		Dextran (mg/ml)		
Colony type[1/]	Isolate	Control	Dextranase-treated[2/]	% Reduction
D	1	.226	0	100
	2	.082	0	100
A	1	.026	0	100
	2	.028	0	100
F	1	.214	.044	79
	2	.225	.036	84
	3	.132	.084	36
B	1	.141	0	100
	2	.042	0	100

[1/]Grown in 10% sucrose broth.

[2/]Dextranase pretreatment consisted of incubation with 100 ppm (v/v) Chaetomium gracile enzyme (450,000 DU/g, Miles Biochemicals) at 50°C for 1 hr.

The type A and D bacteria are by far the most predominant colony types, however, making up at least 95% of the total Leuconostoc population (Table 4). The type D bacteria were also found to be predominant in the Louisiana juice examined by McCleskey et al (26). All strains of type A and D isolated produced dextrans totally destroyed by the enzyme.

The literature on the bacteriology of cane products (1,25,35) indicates that these materials are favorable media for many yeasts, fungi, and bacteria besides Leuconostoc sp. and that some of these produce non-dextran polysaccharides. Non-dextran polysaccharides have been isolated from stand-over cane in Australia (2), Queensland raw sugars (4), red-rotted cane (8), Cuban molasses (6), and even from fresh cane as a response to wounding (38). Some early work from Louisiana

(24) also indicated that Leuconostoc sp. were not always even the predominant organisms in problem cane juice. Counts of Leuconostoc and non-Leuconostoc organisms in three deteriorated crusher juices (Table 5) showed how important the latter may be.

Table 4. Relative numbers of the four Leuconostoc colony types found in deteriorated cane crusher juice.

Sample	Colony type	Number found[1/]	% of total
1	A	1.12×10^5	21.05
	B	4.0×10^3	0.75
	D	4.08×10^5	76.69
	F	8.0×10^3	1.50
2	A	1.32×10^5	32.35
	B	4.0×10^3	0.98
	D	2.64×10^5	64.72
	F	8.0×10^3	1.96

[1/]Each count shown is the mean of two replications.

Table 5. Relative numbers of Leuconostoc and non-Leuconostoc organisms in cane crusher juice.

Replication	Leuconostoc[1/]	Non-Leuconostoc[2/]
1	6.64×10^5	1.28×10^7
2	6.48×10^5	9.76×10^6
3	9.6×10^5	9.12×10^6

[1/]Plate counts were made on Bacto-plate count agar (Difco) containing 10% sucrose and .005% sodium azide.

[2/]Plate counts were made on nutrient agar (Difco).

Based on the enzyme digestion experiments and the information on the microflora of cane products, it was decided to further investigate some of the other organisms present in cane juice. In one trial (Table 6), it was found that 2 of 5 non-Leuconostoc bacteria present at high levels in crusher juice produced products detected as dextran by the haze procedure. More surprising was the fact that 3 of the 5 produced products detected as dextran by the Roberts method.

Table 6. Haze and Roberts responses to products of six organisms isolated from deteriorated cane juice.[1/]

		Dextran			
		Haze		Copper	
Organism	Juice population (cfu/ml)[2/]	ppm	% of Leuconostoc	ppm	% of Leuconostoc
Isolate 1	3.4×10^6	0	0	26	1.1
2	2.0×10^6	303	1.87	1814	75.7
3	2.0×10^6	0	0	582	24.3
4	4.0×10^6	2187	13.49	257	10.7
5	7.4×10^6	0	0	0	0
Leuconostoc	1.11×10^7	16218	-	2395	-

[1/]Organisms grown in 10% sucrose broth.

[2/]Counts done on nutrient agar for isolates 1-5 and on Bacto-plate count agar for the Leuconostoc isolate.

When the products produced by some of the most active of the latter type of organisms were subjected to the dextranase treatment, they were found to be largely unaffected (Table 7). A pure culture of *L. mesenteroides* isolated from deteriorated juice and run in parallel showed no remaining Roberts dextran after the identical pretreatment.

Table 7. Effect of dextranase pretreatment on Roberts dextran data for non-*Leuconostoc* organisms isolated from cane crusher juice.[1/]

Isolate	Roberts dextran (ppm)	
	As is	Dextranase pretreatment[2/]
1	6987	6713
2	3414	2930
8	8467	7910
Leuconostoc	33400	0

[1/]Medium was sterilized crusher juice or 10% sucrose broth.

[2/]Dextranase pretreatment consisted of incubation with 100 ppm (v/v) *Chaetomium gracile* enzyme (450,000 DU/g, Miles Biochemicals) at 50°C for 1 hr.

Some other observations on the Roberts procedure concern the effects of ion-exchange treatment and variation in alcohol concentration. It was found (Table 8) that the use of 50% alcohol (as specified in the haze test) produced a much lower result than 80% alcohol on raw sugars.

Table 8. Effect of alcohol concentration (% v/v) on Roberts dextran results.

Sample	Dextran (ppm)	
	50% Alcohol	80% Alcohol
Raw Sugar #1	625	1476
Raw Sugar #2	1547	2260
Pure dextran (4 x 10^4MW)	512	556
Pure dextran (2 x 10^6MW)	658	628
Leuconostoc D1 product	55976	53863

The literature indicates that over 90% of the raw sugar dextrans are precipitated by 50% alcohol (17,20), but this conclusion was based on the haze test which is incapable of detecting very low molecular weight dextran molecules, should they be present. For this reason, the completeness of dextran precipitation at 50% alcohol was further substantiated using the Roberts procedure and a culture of *Leuconostoc* (colony type D) isolated from deteriorated juice. No increase was noted in the Roberts figures when alcohol concentration was increased (Table 9). It would thus appear that the Roberts figures for the raw sugars include non-dextran polymers which are initially precipitated by the high concentration of alcohol and then presented for discrimination by the copper reagent.

Table 9. Effect of increasing concentrations of alcohol on the Roberts dextran results for a *Leuconostoc* D1 culture.

Alcohol conc. (%)	Dextran (as % of 80% alcohol results)
50	104
60	112
70	103
80	100
90	105

Ion exchange also markedly lowers the dextran detected by the Roberts method even though salts are not recognized as an interference (Table 10). Parallel experiments with dextran produced by a culture of Leuconostoc and with purified dextran (T2000) showed no removal of dextran by the resins in either case. One possible explanation for these data is the presence of charged polymers being detected as dextran by the copper reagent.

Table 10. Effect of ion-exchange pretreatment[1/] on Roberts dextran levels in raw sugars, a Leuconostoc culture, and a standard dextran solution.

Sample	Roberts dextran (ppm)	
	Untreated	Ion-exchanged
Raw sugar #1	1412	213
Raw sugar #2	1922	734
Raw Sugar #3	1398	797
Dextran T2000	1697	1825
Leuconostoc (colony type D)	31648	33766

[1/]Sugar solutions (20g/250 ml), Dextran T2000 solution (50 ml), and a Leuconostoc culture (colony type D) (50 ml) were stirred for 30 min with Amberlite IR-120H and IR-45 resins (4.3g ea).

The original article on the use of alkaline copper to detect dextran in blood (15) warns that cellulose is a potential interference; cellulose is a β-1,4 glucan, while dextran has the very different α-1,6 structure. A recent article in the brewing field (23) in fact details the use of alkaline copper to detect a β-glucan in the presence of starch. It has, however, been pointed out (32) that β-glucans do not normally occur in raw sugars. The incomplete removal of proteins or, more precisely, trichloroacetic acid-precipitable materials from cane juice has also been found to produce inflated estimates for dextran present (27). It thus becomes obvious that the alkaline copper reagent is not specific just for dextrans, but instead relies to a large extent on the absence of interferences in most cane products. Based on our present work, interferences may unfortunately be more common that heretofore supposed.

CONCLUSIONS

Based on these preliminary experiments, we believe that the specificity of both of the dextran methods currently being used for raw sugar settlements is at best questionable. We are continuing these studies in order to more accurately characterize the polysaccharides being measured by the two analytical methods.

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TIME-TEMPERATURE STUDIES--CRYSTALLIZATION FROM FINAL MOLASSES

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ABSTRACT

Work has been completed to set up a computer model of cooling crystallization and to determine the optimum way to cool "C" massecuites.

An optimum cooling profile yields the best possible exhaustion of final molasses within the time period given by the size of the crystallizer and the production rate. Moreover, by avoiding nucleation, such a profile minimizes losses through the centrifugals and provides crystals of a more homogeneous size.

A study of the influence of the Residence Time Distribution (RTD) in crystallizers has also been completed. Experimental work has been initiated to measure the solubility coefficients of various Louisiana, Texas and Florida molasses from the 1984 season. A least-squares correlation is SC = 1.3 - 0.18 I/W - 0.02 RS/A for I/W ratios ranging from 2 to 3.1. Finally, the influence of crystal content on viscosity has been considered as one of the limitations of molasses exhaustion.

RESULTS

Optimum Cooling vs Non-Optimum Cooling

The computer model is based on an empirical equation for sucrose growth rate in impure solutions. This equation was derived by Wright and White (6) in Queensland, Australia. According to this model, there is a maximum in the curve of growth rate vs temperature, at fixed impurity/water (I/W) and sucrose water (S/W) ratios. The maximum occurs because at low temperatures the crystal growth is hampered by the high viscosity of the mother liquor, while at high temperatures it is slowed by the small value of supersaturation (Figure 1). As sucrose crystallizes, the S/I ratio decreases and the maximum shifts toward lower temperatures. The optimum cooling profile (temperature vs time) is the one that guarantees the maximum possible growth rate according to the I/W and S/W ratios. The computer simulation shows that this optimum profile is a decreasing convex function of time (Figure 2). Also shown, in Figure 3, is the time dependence of the difference between the actual and equilibrium purities. It is interesting to note that the supersaturation at the end of the run is very low (a few percent) so that the growth rate is also very low. To illustrate the effects of the cooling profile on molasses exhaustion, we plotted the computer results for linear and concave decreasing temperature profiles, in addition to the optimum curve (Figures 2 and 3). The final molasses purities are respectively 0.8 and 1.9 purity points higher relative to the optimum profile. Figure 4 shows the evolution of supersaturation with time, again for each profile.

Residence Time Distribution

In the 1983 survey of Louisiana factories, it was found at four factories that a considerable spread occurred in retention times of the massecuite (3). This means that each element of massecuite follows its own temperature-time profile; only the initial and final temperature are common to all elements. Since the crystallization rate decays rapidly, little is gained by retaining a part of the massecuite beyond a certain period of time, i.e. approximately 30 hours for our simulations. On the contrary, the fraction of massecuite leaving before having spent 30 hours in the crystallizer will have a somewhat higher purity than that corresponding to the retention time of 30 hours. The net effect is a significant increase in final molasses purities. It was shown, however, using three different flow patterns (gaussian with narrow peak, gaussian with wide peak, and a real pattern - Factory F in reference 3) that the losses are negligible in respect to the plug flow simulation. This occurs because most of the exhaustion is accomplished within the

first few hours and so the purity curve has lost almost all its curvature when the first fraction of massecuite leaves the crystallizer. It should be noted, though, that the validity of this conclusion depends, to some extent, on the numerical values of the parameters of the growth rate equation. The work is continuing to confirm this equation by laboratory-scale experiments and, in the next grinding season, by measurements on the "C" crystallizers at selected sugar mills.

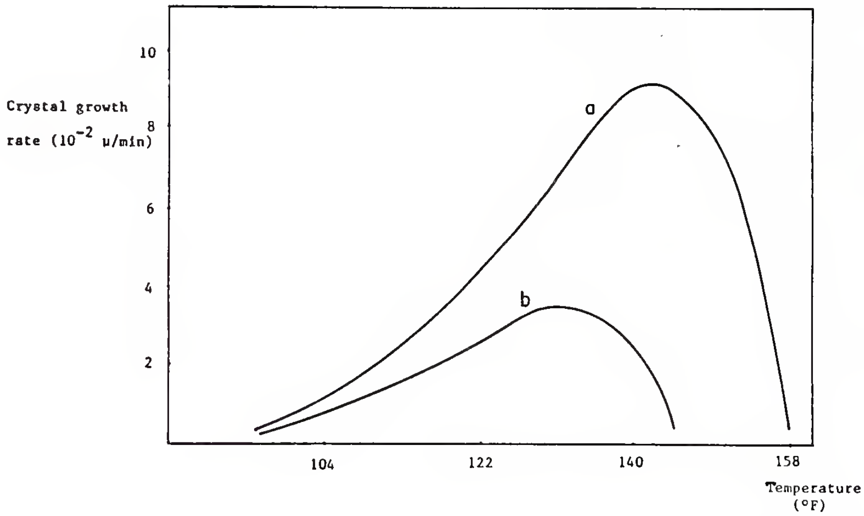

Figure 1. Growth rate vs temperature for two molasses compositions: I/W = 2, a) S/W = 2.4, b) S/W = 2.2. The optimum profile is the locus of maxima of the crystal growth rate curves.

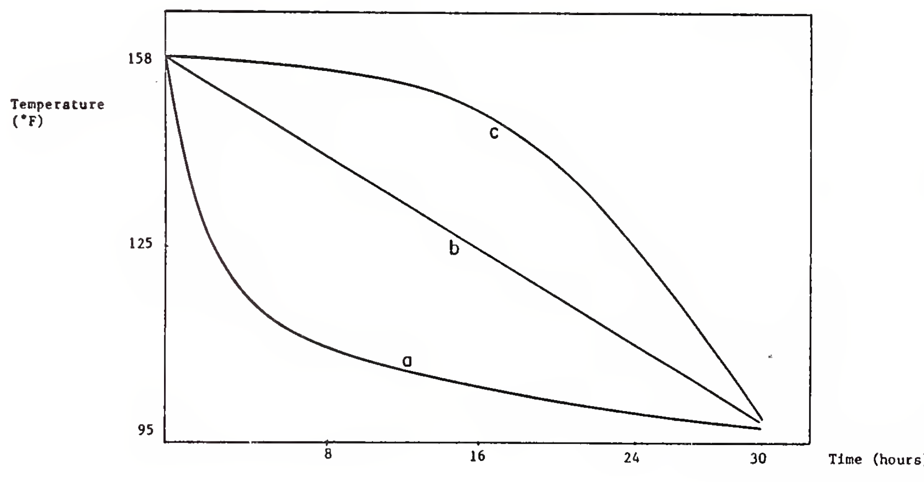

Figure 2. Three time-temperature profiles: a) optimum profile (result of computer simulation, massecuite parameters are given in Fig. 3), b) linear profile, c) concave temperature profile.

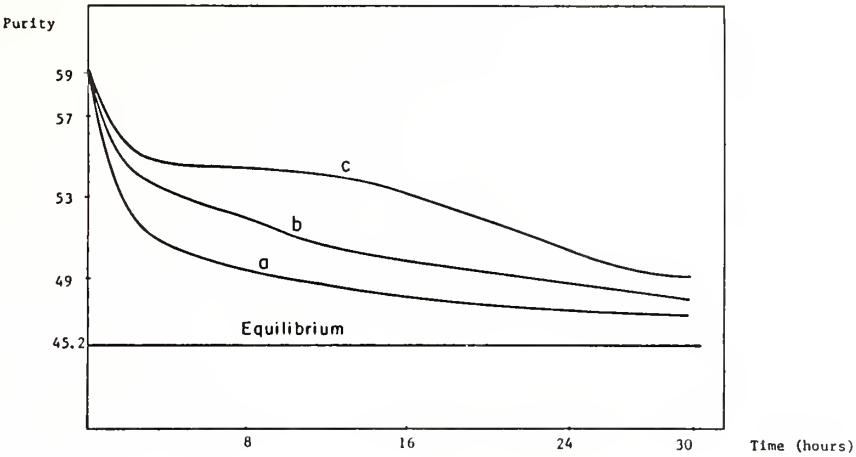

Figure 3. Purity vs time for the three time-temperature profiles of Fig. 2. a) optimum profile (result of computer simulation), b) linear profile, c) concave temperature profile, d) equilibrium purity at the final temperature. Initial massecuite parameters: Temperature 158°F, crystal content 30% (w/w), crystal size 0.1 mm, molasses purity 59%, supersaturation 1.2.

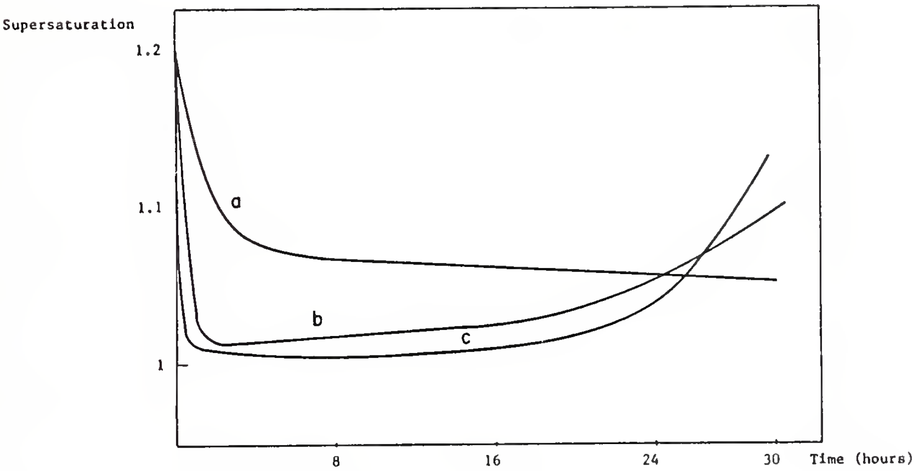

Figure 4. Supersaturation vs time for the three time-temperature profiles of Fig. 2. a) optimum profile (results of computer simulation, b) linear profile, c) concave temperature profile.

Solubility Coefficient Measurements

The solubility coefficent, defined as the ratio (Sucrose/Water) in actual impure solution to the ratio (Sucrose/Water) in pure solution at the same temperature, is of primary interest for our problem because it has a critical effect on supersaturation. Like many other researchers in various countries (Australia, South Africa, Mauritius...), we derived a correlation that gives the solubility coefficient as a function of the Impurity/Water (I/W) and Reducing Sugars/Ash (RS/A) ratios.

To do so, 19 samples from Louisiana, Texas and Florida factories were agitated with excess crystals at 50°C until equilibrium was attained. The equilibrated molasses were analyzed for true sucrose and reducing sugars by the Lane-Eynon method, ash by conductivity and refractometer Brix. The true solids content was then calculated from Brix and true sucrose using a correlation presented in Reference 4. Applying the least squares method to our data yielded the formula SC = 1.3 - 0.18 * I/W - 0.02 * RS/A with correlation coefficient R = 0.53. Due to the small effect of the RS/A ratio, the best correlation using only the I/W ratio, that is SC = 1.29 - 0.19 * I/W has a correlation coefficient of 0.52, almost as good as the double variable coefficient (Figure 5). The small effect of the RS/A ratio at the relatively low I/W ratios of our molasses (of the order of 2.5) is consistent with literature reports from other countries.

The rather poor correlation indicates that the best fit equation can only be used for a rough estimate of the solubility coefficient. Essentially, the scatter occurs due to both the limited accuracy of the analytical methods and the intrinsic variability of the final molasses.

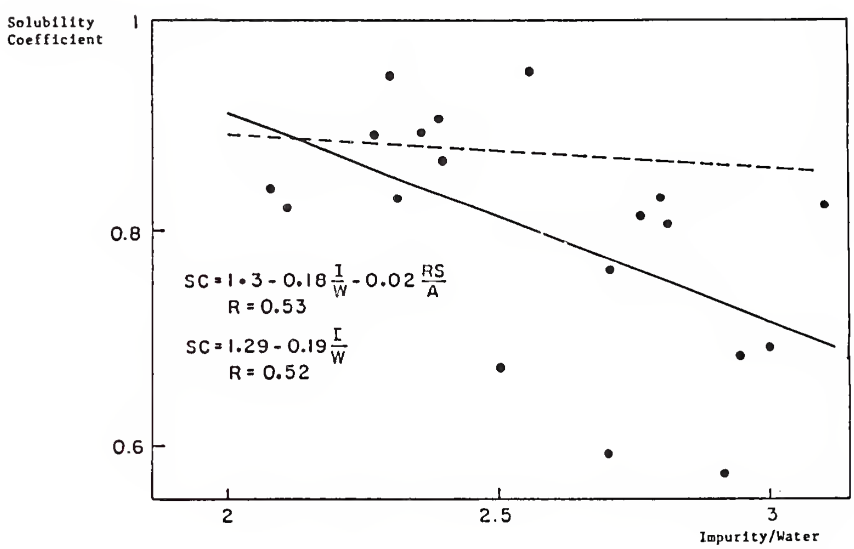

Figure 5. Best linear correlation between solubility coefficient and I/W ratio for 19 Louisiana and Florida final molasses (equation 2). For comparison, recent data (6) is given for South African molasses (----) at RS/A = 1.4 (Louisiana average in 1985).

Viscosity Constraints

There is a limiting value for each factory of the "C" massecuite viscosity that can safely be handled. The usual way to avoid problems with pumping and centrifuging "heavy" massecuites, such as dilution with water and/or heating the massecuite usually lead to an increase in final molasses purity. The empirical formulas of Broadfoot and Steindl (2) (applicability of which was verified for local conditions in our laboratory) and Awang and White (1) were included in the computer model developed in the course of our work in order to evaluate an alternate method based on reducing crystal content of the massecuite. This reduction can be achieved either by dilution of the massecuite with molasses or removing a fraction of the crystals in precentrifugation and recycling the mother liquor. To illustrate the point, we plotted in Figure 6 the history of three massecuites with initial crystal contents of 40, 20, and 15% (w/w) respectively. For a crystallization period of 30 hours, the molasses purity is 0.7 points lower for the massecuite with 40% initial

crystal content compared to the one with 20%. The viscosities of the two respective massecuites are 2820 and 850 Pa.s. Further reduction of the purity loss for massecuite with low crystal content can be achieved if the capacity of the crystallizers permits extension of the crystallization period.

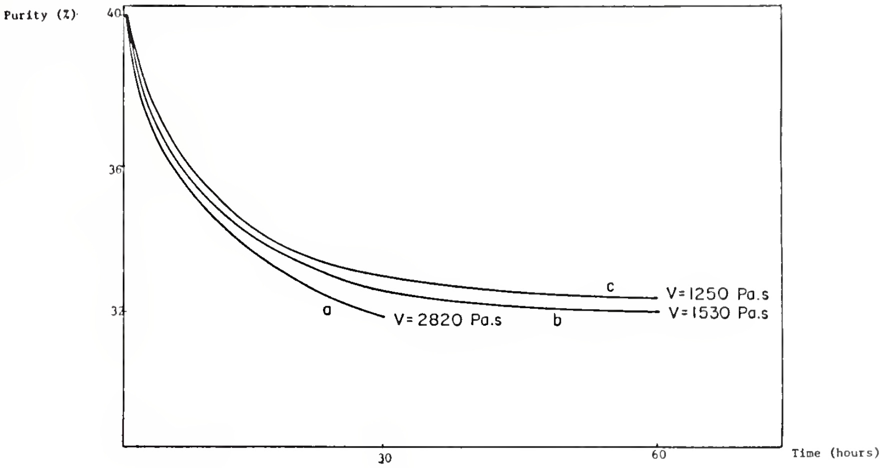

Figure 6. Purity vs time for massecuites of various initial crystal contents. a) 40%, b) 20%, c) 15%. Initial molasses parameters: Temperature 158°F, crystal size 0.2 mm, Purity 40%, supersaturation 1.13. Purities after 30 hours: a) 31.3, b) 32, c) 32.2; after 60 hours: b) 31.4, c) 31.7.

SUMMARY

Work has been completed on a computer model of the "C" crystallizers. Using the model, an optimum cooling profile was determined that leads to the best molasses exhaustion within the available period of time. The effect on molasses exhaustion of the non-ideal flow in the industrial crystallizers that was observed in the 1983 season appears negligible. Experimental work has been initiated to determine the solubility of sucrose in Louisiana, Texas and Florida molasses. It is hoped that the work will eventually lead to a target purity formula suited to local conditions and replace the South African formula currently in use. The effect of crystal content was estimated on exhaustion of final molasses, and a suggestion was made to control the massecuite viscosity by reducing the crystal content of the massecuite.

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AUTOMATIC DETERMINATION OF SATURATION TEMPERATURE OF MOLASSES

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ABSTRACT

Knowledge of saturation temperature is highly desirable for optimum control of vacuum pans, crystallizers and massecuite reheaters. The standard laboratory methods for measuring saturation temperature are slow and tedious. A new method, based on the principle of differential thermal analysis, should permit a direct reading of saturation temperature in a few minutes. The feasibility of the method was demonstrated by solving the appropriate mathematical relations of the non-steady heat-transfer problem. An account is given of the preliminary experimental work done to confirm validity of the model.

INTRODUCTION

The crystallization process in a raw sugar factory is fundamental to the operation of the plant, and the efficiency of sucrose extraction will determine the profitability of the overall processing operation.

The rate of crystallization of sucrose from impure solutions is dependent on the supersaturation of the mother liquor in the liquid/crystal medium. The supersaturation in the mother liquor is a function of temperature and sucrose concentration and cannot be readily measured by a direct means.

While control of supersaturation in the vacuum pan can be accomplished with reasonable accuracy, determination of this parameter in crystallizers and reheating systems for low grade strikes is not easy.

Results of a crystallizer survey carried out in Louisiana in 1984 (1), indicate that both the operation of the cooling crystallizers and reheating systems are not well controlled operations. The data show that (a) the crystallizer cooling profiles do not follow the optimum profile, (b) there are significant purity increases in the mother liquor in the reheating process.

The determination of the saturation temperature, therefore, becomes a critical parameter in the control of these operations.

METHODS

Determination of Saturation Temperature

Several methods of determining saturation temperature already exist, but these techniques tend to be either very slow or rely solely on the expertise of the analyst.

Typical methods are: 1) Determination of solubility coefficient of molasses at a single temperature close to that of the expected saturation temperature and the use of solubility tables to determine the saturation temperature; 2) similar to the above method, but carried out at several temperatures. The solubility coefficient is then interpolated from the solubility temperature curve; 3) direct visual observation of a crystal in molasses as the molasses is heated; and 4) optical transmission techniques for determining the change in light transmission as crystals begin to melt (2,4).

The first two methods are extremely slow and require detailed knowledge of the molasses composition while the third method is critically dependent on the skills of the analyst, and the scatter of the data requires replicate analyses. The fourth method has been used but has still not reached the stage of full commercial development.

The new method described below is based on the principle of Differential Thermal Analysis (DTA). Figure 1 illustrates the instrumental layout of the system. Two cells of the same area and thickness are heated directly using flat heating elements. Cell #1 contains only the molasses under investigation while Cell #2 contains molasses and crystalline sucrose (synthetic massecuite). A related method in a different experimental arrangement has been described by Van Hook (3) but has not been developed further.

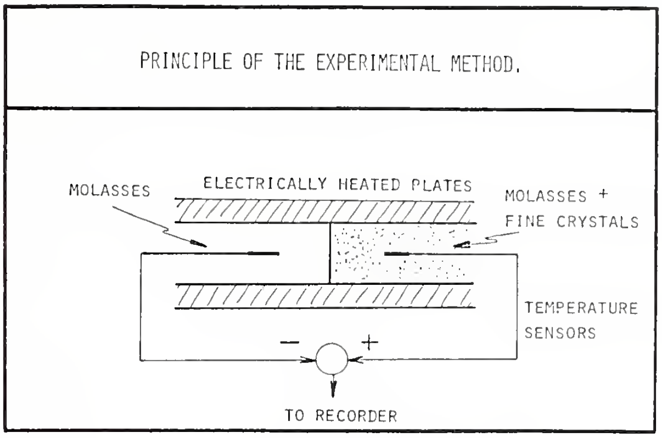

Figure 1. Experimental system for differential thermal analysis.

Thermocouples T_1 (molasses) and T_2 (massecuite) measure the temperature of the materials and are used in a differential mode to provide the temperature difference between the two cells. This temperature difference will be dependent on the thermal capacity of the two cells which should be constant provided crystals neither dissolve or form. When the saturation temperature is reached, the cell containing the massecuite has a higher thermal capacity and hence the temperature of this cell will rise at a slower rate and hence the saturation temperature can readily be determined.

Theory of the DTA Based Determination of Saturation Temperature

The experimental system as shown in Figure 1 illustrates the experimental cell of cross-sectional area A and thickness L. The temperature at any point in the cell will be dependent on the distance from the two heating plates. In this system the thermocouples are placed midway between the plates, i.e. L/2 from them.

The one dimensional heat-conduction equation with a heat generation term

$$k\frac{\partial^2 T(x,t)}{\partial x^2}+\tilde{Q}(x,t)=\rho\, C_p\frac{\partial T(x,t)}{\partial t} \qquad 1)$$

with the initial and boundary conditions

$$T(x,0)=T_o,\ T(0,t)=T_o+ct,\ \left.\frac{\partial T(x,t)}{\partial x}\right|_{x=L/2} = 0 \qquad 2)$$

describes the system illustrated in Figure 1. The heat generation term is

$$\tilde{Q}(x,t) = \Delta H^{dis}\tilde{G}(x,t) \qquad 3)$$

where the dissolution rate G is related to the undersaturation $C(g/cm^3)$ by

$$\tilde{G}(x,t)=KA\Delta C \qquad 4)$$

Both the mass transfer coefficient K(cm/min) and the solid surface A(cm^2/cm^3) are functions of time and position. For dissolution in a stagnant medium, K is inversely proportional to the particle radius R,

$$K=D/R \tag{5}$$

The total solid surface A is

$$A=\beta NR^2 \tag{6}$$

where β is a surface shape factor of the crystals and R their radius. Combination of 4, 5 and 6 then gives

$$\tilde{G}(x,t)=\beta DNR(x,t)\Delta C(x,t) \tag{7}$$

Both R and ΔC can be expressed in terms of the amount of crystals dissolved

$$\Delta G(x,t)=\int_0^t \tilde{G}(x,t)dt \tag{8}$$

The crystal radius, employing a volume factor α is

$$R(x,t)=[R_o^3 - \frac{\Delta G}{\alpha\rho_{suc}N}]^{1/3} \tag{9}$$

The undersaturation ΔC (x,t) is given by

$$C^{eq}(x,t) - C^B(x,t) \tag{10}$$

where the superscripts denote the equilibrium and bulk solute concentrations. Because of the characteristics of crystal growth and dissolution at low purities of the sucrose crystal in the temperature region considered (40-50°C), we postulate that

$$\Delta\tilde{G}(x,t) = 0 \text{ for } C^{eq} < C^B \tag{11}$$

The bulk concentration is an increasing function of time,

$$C^B(x,t)=C_o^B + \Delta G(x,t) \tag{12}$$

The solubility C^{eq} is a function of temperature only,

$$C^{eq}(x,t) = b[T(x,t) - T_o^{sat}] + C_o^B \tag{13}$$

where the temperature coefficient b can be taken as a constant for the considered temperature range. Finally, combination of 7, 8, 9, 10 and 13 gives

$$\tilde{G}(x,t)=\beta DN\ [R_o^3 - \frac{\Delta G(x,t)}{\alpha\rho_{suc}N}]^{1/3}\left\{b[T(x,t) - T_o^{sat}] - \Delta G(x,t)\right\} \tag{14}$$

<u>Solution</u>

An analytical solution is available when $\tilde{Q}=0$. For $\tilde{Q}\neq 0$, a numerical solution was obtained with the IMSL routine DPDES that solves a system of partial differential equations using the method of lines with cubic hermite polynomials. In order to avoid iterations, the amount of crystals dissolved was approximated as

$$\Delta G(x,t) \simeq \Delta G(x,t-\Delta t) \tag{15}$$

where Δt is the time step of the integration (of the order of 10^{-4} minutes).

RESULTS

A sample computer printout is included in Figure 2 with the numerical values used. The results are summarized in terms of the time profile of the temperature at the midpoint between the plates and the amount of crystals dissolved (Figures 3 and 4).

While the line 1 represents temperature increase of a molasses sample without any crystals, 2 and 3 represent respectively extremes of massecuite conditions. It appears that the addition of fine pulverized sucrose to the molasses (or massecuite) is a prerequisite for the thermal effect to be detectable.

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              TEMPERATURE PROFILE BETWEEN TWO HEATED
                INFINITE PLATES WITH ENDOTHERMIC
                     PHASE-TRANSFORMATION

              SYSTEM PARAMETERS ( CM-G-MIN-CAL-DEG C )

                  PLATE SEPARATION                  =   0.200
                  INITIAL TEMPERATURE               =  41.600
                  HEATING RATE                      =   1.000
                  THERMAL CONDUCT OF MASS           =   0.050
                  DENSITY OF MASS                   =   1.500
                  SPEC HEAT OF MASS                 =   0.450
                  CRYSTAL VOLUME FACTOR             =   0.360
                  CRYSTAL SURFACE FACTOR            =   3.100
                  INITIAL CRYSTAL RADIUS            =   0.20E-03
                  NUMBER CRYSTALS PER CC            =   0.33E+11
                  DIFF COEFF OF SUCROSE             =   0.60E-03
                  TEMP COEFF OF SOLUBILITY          =   0.012
                  CRYSTAL DENSITY                   =   1.590
                  SATURATION TEMPERATURE            =  42.000
                  INITIAL WT FR OF CRYSTALS         =   0.100
                  HEAT OF DISSOLUTION               =  -14.600

              RESULTS GIVEN

                1. TEMPERATURE
                2. TEMPERATURE WITH NO CRYSTALS
                3. SPACE DERIVATIVE OF TEMPERATURE
                4. PER CENT SOLID REMAINING
                5. RADIUS OF SOLID REMAINING X 10000
                6. DISSOLUTION VELOCITY X 100


   TIME =    0.200E+00
   POSITION FROM WALL =
        0.0          0.020        0.040        0.060        0.080        0.100
      -----------------------------------------------------------------------
1.   41.77544     41.75185     41.73355     41.72057     41.71278     41.71021
2.   41.80000     41.76671     41.74115     41.72308     41.71233     41.70876
3.   -1.31313     -1.04702     -0.78160     -0.51854     -0.25900      0.0

   POSITION FROM WALL =
      0.0      0.004     0.016    0.0       0.024     0.036    0.0       0.044
        0.056     0.0       0.064     0.076    0.0       0.084     0.096     0.100
      -----------------------------------------------------------------------
4.  100.000  100.000  100.000  100.000  100.000  100.000  100.000  100.000
       100.000  100.000  100.000  100.000  100.000  100.000  100.000  100.000
5.    2.000    2.000    2.000    2.000    2.000    2.000    2.000    2.000
        2.000    2.000    2.000    2.000    2.000    2.000    2.000    2.000
6.    0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
        0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
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Figure 2. Computer print-out of differential thermal analysis model.

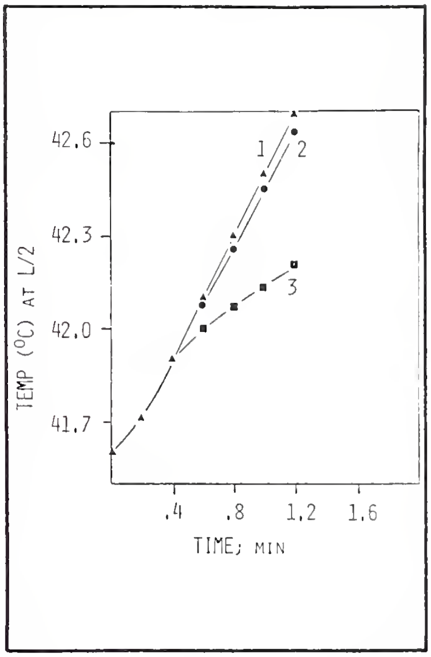

Figure 3. Theoretical predictions of massecuite temperatures as a function of time.
Curve 1: molasses with no crystals.
Curve 2: 10% w/w crystals, crystal radius 100 microns, diffusion coefficient of sucrose, D, 10^{-6}cm^2/sec.
Curve 3: 10% w/w crystals, crystal radius 4 microns, diffusion coefficient of sucrose, D, 10^{-5}cm^2/sec.

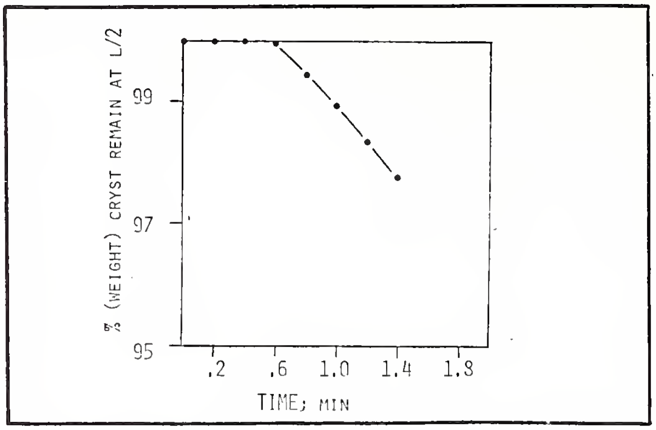

Figure 4. Theoretical prediction of crystal dissolution as a function of time.

EXPERIMENTAL DETAILS

The initial experiments were carried out using a single cell unit to accommodate the available heating elements. The cell size was 3.6cm x 3.6cm x 0.4cm and was fitted with a .07cm thermocouple located at the center of the cell midway between the plates.

The heating elements have a maximum capacity of 45 W and are mounted on 3mm brass plates to provide uniform heat distribution. The heating rate could easily be adjusted by controlling the supply voltage and was set such that the temperature rise was about 2°C per minute.

Figure 5 shows a typical time/temperature curve for a molasses sample. The slight non-linearity of the relationship is mainly due to radiation losses since the initial system could not be completely insulated. A similar curve is obtained when a massecuite is used.

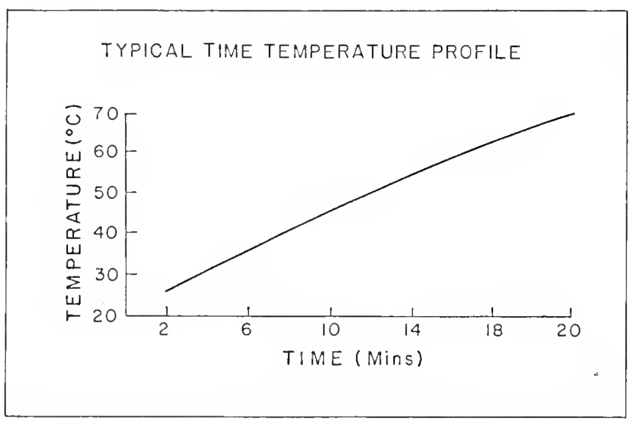

Figure 5. Experimental time-temperature relationship for heated massecuite.

However, if the two curves are superimposed, the initial parts of the curves coincide, but they diverge as the temperature increases. Figure 6, curve 1 shows the temperature difference between these curves, plotted as a function of massecuite temperature, and it shows a distinct change in slope. This particular massecuite contains 10% by weight of 5 micron crystals providing a large surface area. Curve 2 in this figure shows the temperature difference for a massecuite containing 30% by weight of 'C' sugar (this is close to a commercial massecuite) and shows an even more distinct breakpoint.

The saturation temperature of the molasses as determined by visual observation of crystal surfaces in molasses is about 47°C and agrees closely with the DTA values.

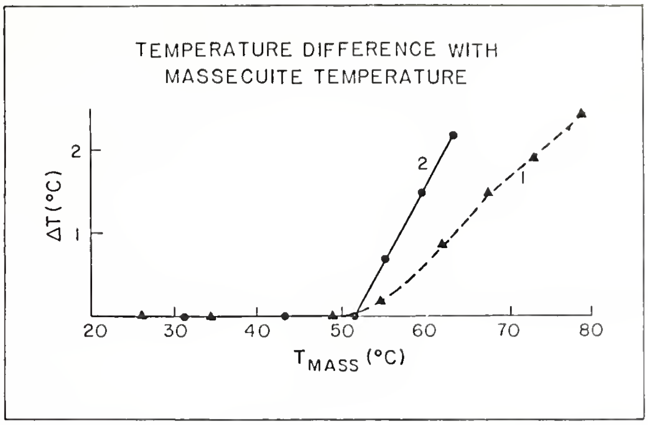

Figure 6. Experimental massecuite - molasses temperature differences.

CONCLUSIONS

From similar tests carried out on other samples, it is encouraging to note the agreement between the values obtained by DTA and visual means (method 3).

Further development is presently underway using a two-cell system as well as a more sophisticated system using only one cell, and it is hoped to have these completed in the near future.

Also under investigation is a system which uses the concept of direct heating of the massecuite with a constant power device.

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SUBSURFACE DRAINAGE SLOWS SUGARCANE YIELD DECLINE

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Seven experiments were conducted in South Louisiana from 1967 through 1984 to determine the effects of subsurface drainage on sugarcane and sugar yields. Each experiment consisted of two treatments; drained (subsurface drained) and nondrained (not subsurface drained). The drained and nondrained treatments resulted in relatively low and high water tables, respectively, in the experimental areas. The experiments and their respective areas were: one experiment on 0.01 acre plots through four ratoons; two experiments, one on 0.01 acre plots and the other in a 10-acre field, were through three ratoons; and four experiments in 1-acre or larger plots through two ratoons. Normally, only two ratoons are grown in Louisiana because yields decline below profitable levels after the second ratoon.

In each experiment, the average cane and sugar yields from the subsurface drained areas were higher than those from nondrained areas. Furthermore, the annual decline in yields occurred at a much slower rate in the subsurface drained areas. The rate of yield decline was determined by correlating yields with years for each experiment.

The rate of cane yield decline from all seven experiments averaged 6.9 and 3.1 tons of cane per acre per year from the nondrained and drained treatments, respectively. Based on these data, typical yields from a nondrained field would be 35 T/A, 28.1 T/A and 21.2 T/A for the first three years and yields from a subsurface drained field would be 35 T/A, 31.9 T/A, 28.8 T/A, 25.7 T/A and 22.6 T/A for the first through fifth year. Additional ratoon crops, which these data show could be obtained with subsurface drainage, would be an economic boost to sugarcane growers in Louisiana because replanting sugarcane is an expensive operation.

The rate of sugar yield decline averaged 1,167 pounds and 767 pounds per acre per year for nondrained and drained areas, respectively. Based on these data, typical sugar yields from a nondrained field would be 5,000 lbs/A, 3,833 lbs/A, and 2,666 lbs/A for the first three years and yields from a subsurface drained field would be 5,000 lbs/A, 4,233 lbs/A, 3,466 lbs/A, and 2,699 lbs/A for the first through fourth years.

This experiment shows that the subsurface drainage slows the rate of decline in cane and sugar yields and increases the number of economically feasible ratoon crops. This additional economic benefit from subsurface drainage should enhance the use of subsurface drainage for sugar production in Louisiana.

PROGRESS REPORT ON SUGARCANE PLANTING STUDIES WITH MINIMUM TILLAGE

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Two experiments were conducted to examine planting techniques and sugarcane yields in plots that were not conventionally tilled before planting. In the first experiment, pasture grass was killed using glyphosate acid (3.0 lb/ac a.i.), subsoiled, and furrows were opened in the area over the subsoil slot. Four sugar cane cultivars were planted October 31, 1983, using mechanically harvested seed cane in conventional and wide-type furrows on standard 5-ft. row spacings. Erectness ratings, sugar yields, and cane yields were determined at harvest December 18-19, 1984. Results showed that cane yield differences occurred among cultivars, but no significant cane yield differences were detected between furrow width treatments.

In the second experiment, sugarcane stubble regrowth was sprayed with glyphosate acid (2.7 lb/ac a.i.) at the 4-6 leaf stage. Row middles were subsoiled after spraying and furrows were opened in the area over the subsoil openings. Three sugar-cane cultivars were planted in late December 1983 using mechanically harvested seed cane. The cane was havested for yield in early January 1985 with yields similar to those expected in successively-planted cane. Complete stubble kill was not obtained after spraying and two disc cultivations did not completely eliminate the old stubble as regrowth was observed after harvesting. Surprisingly, enough soil was available to cover the seed cane and good cane yields were produced using minimum tillage practices.

THE RESPONSE OF SUGARCANE GROWN IN ROTATION WITH RICE TO CALCIUM

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Rice is grown in rotation with sugarcane. Both rice and sugarcane have been shown to benefit from calcium silicate slag application prior to planting. A study was conducted to determine whether calcium silicate slag applied before planting the rice would bendfit the following crop of sugarcane.

Using small plots suitable for rice experiments, treatments consisted of 1) a check, 2) calcium silicate slag broadcast at 5,000 kg/ha prior to rice planting, 3) calcium silicate slag broadcast at 20,000 kg/ha prior to rice planting, 4) calcium silicate slag broadcast at 5,000 kg/ha before planting sugarcane, and 5) calcium silicate slag broadcast at 20,000 kg/ha prior to planting sugarcane.

The calcium silicate slag applied prior to rice that preceded sugarcane and calcium silicate slag applied just before sugarcane planting increased sugarcane leaf tissue silicon in June and October samplings. Application immediately before sugar cane planting, however, resulted in significantly higher tissue silicon than application before the rice crop. No yield responses were recorded, perhaps due to the small plot size and to rodent damage.

DIFFERENTIAL SURVIVAL OF SUGARCANE SEEDLING PROGENIES FOLLOWING WINTER FREEZE DAMAGE

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Sugarcane seedlings are selected in the plant cane crop of most sugarcane breeding programs of the world; however, Louisiana seedlings are selected in the first ratoon crop after an overwintering cycle. Overwintering presumably will exert some selection pressure for ratooning ability. Near-record freezes of 13° F occurred during the two consecutive winters of 1983-84 and 1984-85 resulting in unusually severe damage to the stubble of seedlings. Survival counts in the spring of 1984 at Houma, Louisiana, showed mortality rates which differed among crosses according to breeding generation and genetic makeup. In general, basic crosses including F_1, BC_1, BC_2, and BC_3 progenies of <u>Saccharum spontaneum</u> X interspecific hybrids showed a higher proportion of survival than commercial crosses. Average survival among first-ratoon seedlings of 57 basic crosses in the 1983 series was 51.1 percent (range 13-90 percent) while survival in a comparable group of 57 commercial crosses was 26.2 percent (range 3-75 percent). Within the basic crosses, survival appeared to decrease with succeeding backcross generations. Survival in progenies of 12 F_1 crosses averaged 71.2 percent whereas 45 advanced progenies (BC_1, BC_2, or BC_3 generations) averaged 47.7 percent.

TESTING SUGARCANE VARIETIES FOR BRITTLENESS

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The selection and release of non-brittle sugarcane varieties (resistant to breakage) is important because varieties grow very rapidly during summer months and are susceptible to top breakage from hurricane force winds. Stalk breakage of brittle varieties causes problems for growers when the cane is cut and planted mechanically during late summer and early fall, and also result in the economic loss of sugarcane left in the field at harvest. To measure breakage, commercial and candidate sugarcane varieties were subjected to three methods for testing brittleness; stalk breaking device (SBD), a device which measures the deflection of a stalk before breakage, and two external wind sources, a trailer-mounted air boat and a helicopter. Results obtained with the SBD during August indicated the variety, NCo 310 was least brittle and CP 72-356 was most brittle, while in October, the newly released variety CP 76-331 and CP 74-383 was less brittle than NCo 310, and CP 72-356 was again the most brittle. The use of a trailer-mounted airboat resulted in significant differences between varieties in top breakage as well as breakage at the base of the stalk during tests conducted during August and October. Breakage at the base of the stalk was 85 percent in August and 58 percent in October

with the unreleased variety CP 78-304. In a third test, a small helicopter which is normally used for applying pesticides was used to measure brittleness on five commercial and one experimental sugarcane varieties during August of 1984. The helicopter was allowed to hover a few feet above the sugarcane canopy for one minute. The variety CP 72-356 was more brittle than the other varieties tested, with 75 per cent of its tops broken. The results of the three methods of testing confirmed that CP 72-356 was the most brittle commercial variety tested.

COLONIAL AND CELLULAR MORPHOLOGY OF SPORIDIA OF USTILAGO SCITAMINEA

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Sporidia of *Ustilago scitaminea* isolated from two different sources were compared and found to have marked differences in their colonial and cellular morphology. Teliospores collected from smut whips on sugarcane in Louisiana were germinated on potato dextrose agar (PDA). Sporidia were separated by either conventional double streaking from microcolonies or subculturing from single sporidia isolated by micromanipulation, and were then transferred to and maintained on PDA. Identical results were obtained with either method of sporidial isolation. Other than a more rapid rate of growth, no morphological differences were apparent when sporidia were incubated at 30° C as compared to 20° C. Colonies are irregular, raised, brownish, and dried in appearance after 48-72 hours incubation and contain sporidia of different sizes. Prolonged incubation (7-10 days) produces a large colony with a dark margin. These colonies contain numerous sporidia of different sizes and long intertwined filaments which do not form a mycelium. A white mycelial mat does form when sporidial colonies of opposite matine type are mixed and incubated. Sporidia isolated also from Louisiana fields by another group differ in size and shape as well as colonial characteristics. Both sets of sporidia can be mated to the other to give typical white mycelial mats indicating genetic compatibility between the two sets of isolates.

SPORIDIAL COMPATIBILITY AND HYPHAL DEVELOPMENT OF USTILAGO SCITAMINEA, CAUSAL AGENT OF SUGARCANE SMUT

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Inconsistencies in the literature concerning sporidial compatibility and in vitro colony morphology prompted this study of *Ustilago scitaminea* Sydow. Teliospores collected from smut whips on sugarcane in Louisiana during the summer of 1984 were germinated on water agar. The sporidia were separated and transferred individually to potato-dextrose agar (PDA) where the survivors budded to produce a cream-colored, smooth-surfaced colony. Short chains of yeast-like cells were observed, but no hypha was formed. Sporidial colonies were mated using the Bauch technique. The results showed that compatibility was controlled by a plus-minus bipolar system. Both bipolar and tetrapolar systems have been reported in *Ustilago scitaminea*. Single sporidial colonies paired in all possible combinations gave a ratio of 1:1, for compatible to incompatible reactions. Compatible and incompatible mating reactions were observed among sporidia collected from the same promycelium. Hyphae were produced when compatible sporidial colonies were mated on malt agar and white, appressed, mycelial colonies developed when tips from these hyphae were transferred to PDA. Within the mycelial colonies there were clusters of large sporidia-like cells that produced mycelium when subcultured. Spordia have been observed to mate while attached to a promycelium and to produce enlarged cells. When transferred individually to PDA, these large cells produced mycelial colonies.

OLIGONYCHUS STICKNEYI (McGREGOR) A MITE PEST OF SUGAR CANE IN FLORIDA

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Surveys conducted during 1984 and 1985 indicated that the primary mite pest of sugarcane leaves in Florida is *Oligonychus stickneyi* (McGregor). Colonies of *O. stickneyi* were most prevalent during the spring and were found only on the lower surface of leaves. Lower leaves were usually colonized first. Estimates of the leaf area colonized by mites on individual leaves ranged from 1 to 466 sq. cm. Damage to leaves by *O. stickneyi* was characterized by stippled, light-colored areas where mite colonies and feeding occurred; these stippled areas usually began to turn red-brown in color (russetted) in about a week. The speed and spread of russetting along a leaf appeared to be dependent on the number of feeding mites

as well as the length of time mites were present. Extensive russetting resulted in leaf death, and mild infestations sometimes caused extensive damage to cane leaves within several weeks. Some varieties appeared to be more susceptible than others to outbreaks of *O. stickneyi*. Two predaceous mites were found in close association with colonies of *O. stickneyi*. *Neoseiulus umbraticus* (Chant) was very common and appeared to be an important mortality factor of *O. stickneyi*. The other predaceous mite, *Fundiseius cesi* (Muma), was common during late spring but was less abundant than *N. umbraticus*.

OVERWINTERING OF SMUT-INFECTED SUGAR CANE IN LOUISIANA

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Survey results indicated that during 1984 the mean level of sugar cane smut infection was higher in plant-cane than in ratoon-cane fields of CP 65-357, CP 73-351 and CP 74-383. This is an atypical pattern for smut disease development. To study the overwintering of smut-infected sugarcane, completely smutted and smut-free cane stools were mapped in commercial plant-cane fields of CP 65-357 and CP 74-383. In both, the rate of stool survival and number of shoots/stool were each lower for smut-infected than smut-free stools following the severe 1984-1985 winter. Results from single stool plantings of CP 73-351 and CP 74-383 were similar. Apparently, cane stools infected by *Ustilago scitaminea* do not survive rigorous Louisiana growing conditions, such as those which occurred during the last two years, as well as smut-free stools.

YIELD COMPONENTS OF *SACCHARUM* AND RELATED GENERA IN THE F_1 AND THREE BACKCROSS GENERATIONS

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A study was conducted to measure the yield components of 125 selected clones of *Saccharum spontaneum* and *S. robustum* and the related genera *Miscanthus sinesis* and *Sclerostachya fusca* in the F_1, BC_1, BC_2 and BC_3 breeding generations. Yield components measured included: number of stalks per plot, mean weight, length and diameter (at top, middle and bottom of the stalk) and Brix. Apparent sucrose purity, commercial recoverable sugar per ton of cane (CRS/TC) and fiber content were also measured. The response of each breeding generation was compared to three commercial varieties; CP 48-103, CP 65-357 and CP 70-321.

WHY LOUISIANA SUGARCANE BORERS GENERALLY ARE MORE NUMEROUS IN FIELDS OF COARSE THAN FINE TEXTURED SOILS

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Changes since 1960 in species composition of Louisiana cane field ant fauna are reported. The need for and frequency of insecticide treatments to control the sugarcane borer is inversely proportional to the abundance of foraging ants in sugarcane fields. Ants are significantly more abundant in clay than in loam soils. The relationships between the abundance of foraging ants and various chemical and textural soil characteristics are examined along with other ecological factors.

SOILS USED FOR SUGARCANE PRODUCTION IN LOUISIANA

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The commercial production of sugarcane in Louisiana is restricted to a smaller number of soils than other agronomic crops grown in the state. The largest acreage is on soils developed in recent Mississippi River alluvium deposited during the last 2,500 to 3,000 years. Large acreages are also grown on soils developed in older Mississippi River alluvial deposits that are about 3,500 to 4,500 years old. Soils developed in loess (aeolian) deposits blown out of the Mississippi River floodplain and deposited on adjacent areas some 10,000 to 20,000 years ago are of tertiary importance with respect to sugarcane acreage. Limited areas of soils

developed in recent Red River alluvium are also used for sugarcane production. The described differences in ages and parent materials together with other factors result in a wide range in characteristics of the soils and in practices that result in their optimum utilization and performance in sugarcane production.

Physical, chemical and mineralogical characterizations have been completed on a number of each of the individual soils used in sugarcane production. The characterizations include individual soil horizons to a depth of at least 3 feet in each soil. In addition, depths and duration of water tables in the different soils have been established as have also landscape positions and relationships. This information is used to group the soils into categories that reflect sugarcane yield potentials and the individual soil properties and characteristics that most limit yields. Yield-limiting soil parameters identified include soil pH, soil fertility, excess amounts of certain elements, excess soil moisture (water tables), and soil moisture deficits. The groupings are useful in prioritizing research needs, evaluating the applicability of research results obtained on one soil to other soils; management decision making; selecting specific soils for conducting field research; and in selecting soils and sites for evaluating potential performance of new cultivars.

EVALUATION OF GENOTYPE BY ENVIRONMENT INTERACTION IN THE LOUISIANA SUGARCANE YIELD TRIALS

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Data from the Louisiana Sugarcane Outfield Variety trials from 1977 to 1984 were analyzed for year, location, and genotype effects. Yield of sugar per acre and the components sugar per ton of cane, and tons cane per acre were analyzed for plant cane, first ratoon and second ratoon crops. Deleting genotypes and/or locations not complete with a year-pair-location combination generated balanced data enabling certain computations. This typically removed experimental and other highly variable genotypes. Variance estimates were thereby conservative. Analyses of variances commonly showed significant genotype by environment interactions especially year X location X genotype effects. Variance components across all four year-pairs, 1977-1978 to 1983-1984, were estimated for year, location, year X location, year X genotype, location X genotype and year X location X genotype effects. Estimates varied considerably with crop, dependent variable and effect.

Several statistics were calculated to estimate the stability of individual genotypes across environments. Statistics included Shukla's stability variance parameter, mean, CV, range, minimum, percentile rank and percent not significantly less than the best genotype or mean of two check genotypes (CP 74-383 and CP 70-321) within an environment. It appears a genotype's mean performance and percent not significantly less than the check genotype within each environment may be the easiest and most lucid method of evaluating the performance of a genotype across environments.

TOLERANCE OF SIX SUGARCANE CULTIVARS TO ASULAM, DALAPON, AND MSMA

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In field experiments, the Louisiana cultivars CP 65-357, CP 70-321, CP 72-356, CP 72-370, CP 73-351, and CP 74-383 were sprayed over the top with herbicide treatments that are effective for postemergence control of johnsongrass and other weeds. Asulam at 3.7 kg ae/ha, a normal rate and 6.7 kg ae/ha, dalapon at 5.0 kg ae/ha and monosodium methane arsonate (MSMA) at 4.5 kg ai/ha were applied initially in April 1983 on the first ratoon when plants were about 51 cm tall and reapplied to the same plots in June 1984 on the second ratoon when plants were about 112 cm tall. In the first ratoon, the yields of cane and sugar/ha from treated plots, as compared to nontreated, handweeded plots, showed that cultivars were affected differentially by dalapon, but that asulam and MSMA did not affect yield of any cultivar. Dalapon caused a yield reduction of 2 to 4 percent for CP 65-357, CP 72-370, and CP 73-351, relatively narrow-leaf cultivars, and of 8 to 10 percent for CP 72-321, CP 72-356, and CP 74-383, relatively broadleaf cultivars. In the second ratoon, dalapon and MSMA reduced yield of all cultivars by about 8 per cent to 15 per cent, respectively, probably because of the relatively late treatment date. Asulam treatments did not significantly affect yields. The experiment is being repeated.

EMERGENCE AND YIELD OF 2,4-D TREATED SEED CANE

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Application of 2,4-D to sugarcane for morningglory control is sometimes necessary to facilitate mechanical harvesting. This practice, however, may have a negative effect on sugarcane harvested for seed cane. The effects of 2,4-D on emergence and subsequent yield of this seed cane were investigated at the Glenwood Plantation in Napoleonville, Louisiana in 1983 and the St. Gabriel Research Station, St. Gabriel, Louisiana in 1984. Nine varieties were treated with 2,4-D (2.0 lb a.i./a) at 2 and 5 weeks prior to harvest in 1983 and 3 and 6 weeks prior to harvest in 1984. Sugarcane stem density was determined in June (8 months after planting) and at time of harvest for 1983 treated sugarcane and in April (6 months after planting) for 1984 treated sugarcane.

Overall, the population density and yield of 1983 treated cane was reduced by application of 2,4-D regardless of application time. Stalks per acre, tons of cane per acre and commercial sugar were reduced 23, 22 and 24 percent, respectively. Specifically, maximum reductions in population density and yield were observed in CP 79-383 and CP 70-321. Emergence data for 1984 treated cane will also be reported. These data indicate that a layby application of atrazine may be a better alternative for broadleaf weed control in seed cane.

ACCELERATED PREDICTION OF STUBBLING ABILITY OF SUGARCANE VARIETIES IN LOUISIANA

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The stubbling ability of experimental varieties is of major concern to the Louisiana Sugarcane Variety Improvement Program. Selection and testing for this characteristic in Louisiana is the major cause of the large time span (14 years) between hybridization and release of a commercial variety to the industry. If stubbling ability could be predicted more efficiently, that time span could be reduced.

During the 1983 and 1984 harvesting seasons, the hypothesis that the stubbling ability of a sugarcane variety can be predicted in first stubble by subjecting the plant cane crop to multiple cuttings was tested. To test this hypothesis, 7 commercial varieties of known stubbling ability were subjected to 4 cutting regimes in the plant cane crop. The succeeding year the cane was grown following normal cultural practices. Within each cutting regime, varietal yield differences were statistically analyzed and compared to expected commercial performance. The best stubbling variety, CP 74-383, yielded best of all cutting treatments. The good stubbling varieties generally performed better than the other varieties in most cutting treatments. There was no clear distinction of performance between the medium and poor stubbling varieties.

POTENTIAL INFLUENCE OF SWEET SORGHUM AND CORN PRODUCTION ON MANAGEMENT OF THE SUGARCANE BORER IN SOUTH LOUISIANA

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Research conducted by the Louisiana Agricultural Experiment Station has demonstrated the likelihood for major enhancement of populations of the sugarcane borer, *Diatrae saccharalis* (F.), where sweet sorghum and corn might be grown in sugar cane producing areas. Early and late plantings of sweet sorghum and corn with moderately resistant (CP 65-357) and susceptible (CP 61-37) sugar cane revealed a 40 percent increase in pupal production in sorghum, and a 3-fold increase in corn as compared to CP 65-357. Studies with arthropod predators indicated that several important groups of insects were less abundant in the 2 annual crops. Though preliminary studies with adults indicated an enhanced egg laying of moths reared from corn, ovipositional preference studies have not been conducted.

Season-long monitoring of borer infestations in the Breaux Bridge/Henderson area during 1983 showed a 2-X higher infestation in sorghum, and a resultant 21,835 (SE ± 2,300--sorghum) vs 5,440 (SE ± 1,979--cane) adults emerged per hectare ($P<0.05$), respectively. Factors which appear to be associated with these results include host plant characteristics, predation, and insecticide control efficacy differences between the crops. Future research is expected to reveal the feasibility of integrating varietal resistance, planting location, planting density, and other cultural practices into a system to effectively manage this key insect pest and facilitate the compatible production of sweet sorghum, and possibly corn, in sugarcane areas.

EVALUATION OF DALAPON AND ASULAM FOR BERMUDAGRASS CONTROL IN SUGARCANE

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Field studies were conducted in 1983 and repeated in 1984 to evaluate dalapon applied alone and in tank-mix with asulam as a directed postemergence spray for the control of bermudagrass growing in sugarcane [cultivar 'CP 70-330' (1983) and 'CP 70-321' (1984)]. Dalapon applied at 4.6 lb/a on a 36 inch band on May 9, 1983, and April 24, 1984, reduced the bermudagrass infestation by 31 and 51 percent, respectively when compared to the untreated check plots. Where dalapon at 4.6 lb/a was reapplied 4 to 5 weeks later, a 94 and 69 percent reduction in the bermudagrass infestation was obtained in 1983 and 1984, respectively. A single tank-mix application of dalapon and asulam at 4.6 and 3.3 lb/a in the spring resulted in a 73 percent reduction in the bermudagrass infestation level in 1983. Significant reductions in the bermudagrass infestation level over that observed with dalapon applied alone was not observed in 1984 when the tank-mix application was made 2 weeks earlier (April 24) to slower growing bermudagrass. An increase in stalk populations was noted for all treatments when compared to the untreated check. However, this increase in stalk population did not result in a consistent yield increase (tonnes) suggesting some phytotoxicity, primarily from the dalapon. If more selective herbicides are not developed and/or labelled, use of the dalapon and asulam tank-mix may be an alternative means of suppressing bermudagrass and minimizing exposure to dalapon injury by eliminating the need for a follow-up application.

THE USE OF A MATHEMATICAL OPTIMIZATION MODEL TO ASSESS RESOURCE ALLOCATION FOR MAXIMUM PROFIT ON COMMERCIAL SUGARCANE FARMS IN LOUISIANA

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The development of a flexible mathematical model to assess the cost and profit structure of commercial sugarcane farms has provided insight into the resource allocation adjustments required for maximum profit. The modular structure of the model makes it extremely flexible, and adaptable to any resource situation found in the sugarcane producing region. This model has the capability to determine optimum growth paths for sugarcane farms, as well as provide information on optimum resource allocation adjustments for changes in exogenous factors, such as the price of sugar, cost of inputs or the development of new technology. This model provides a useful management tool enabling the farm operator to anticipate potentially favorable or unfavorable resource use situations. To illustrate the usefulness of the model in detecting unfavorable farm sizes in a farm growth path, the optimum growth path for sugarcane farms in the Teche region of Louisiana was developed. The results of the analysis show up those unfavorable farm sizes due to the lumpy nature of major equipment items. This model should prove to have some very useful research and commercial applications for the sugar industry.

SACCHARUM HYBRIDS FOR EROSION CONTROL?

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High-fiber sugarcane hybrids (e.g. L 79-1002) have been tested successfully for several years to determine their potential as energy and sugar crops. L 79-1002 has also proven to be very effective for bank stabilization of fish and crawfish ponds and as a screen around these ponds. After two years of testing, it has proven to be the most salt tolerant of all sugarcane varieties tested. Recent greenhouse tests have shown that it can grow in soils with salt levels reaching 20,000 ppm. Both plants and roots showed serious damage, and in some cases death, after this level. It is believed that this variety has potential for possible use along coastal marshes of Louisiana for bank stabilization and erosion control.

ELECTRICAL CONTROL FOR HYDRAULIC CYLINDERS IN HARVESTERS

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The objective of this work was to design and build an electrical control for hydraulic cylinders operated by solenoid valves. Also, this system could be used in the future for automatic control of other hydraulic functions in harvest machines.

The system was mounted on a sugarcane harvest machine to operate the height control for the topper blade. Performance and reliability was studied, and will be presented in the paper.

EFFECT OF FREEZING TEMPERATURES ON SOME IMPORTANT SUGARCANE VARIETIES IN FLORIDA

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A severe freeze occurred on January 22, 1985 and caused damage to the sugarcane crop in South Florida. Samples of ten commercial varieties were taken weekly starting one week after the freeze to determine the effects of freezing temperatures on juice quality. Brix, percent sucrose, percent purity, kilograms of sugar per metric ton of cane, pH and titratable acidity were analyzed from 5-stalk samples taken weekly for 6 weeks. The results showed that the rate of deterioration of these traits varied among varieties. Six varieties, CL 54-378, CL 59-1052, CL 61-620, CP 63-588, CP 72-1210 and CP 74-2005 had relatively low rates of deterioration whereas two varieties, CP 70-1133 and CP 73-1547, had relatively high rates of deterioration. Differences in growth type and morphological characteristics might have affected the degree of freeze damage and subsequent deterioration when the freezing temperatures were less severe. Cold damage was less in some varieties that lodged severely and had heavy trash or varieties that produced very dense stands that retarded penetration of the cold or provided good cover to prevent loss of soil heat.

SUGARCANE GROWTH AND RATOON STUNTING DISEASE RESISTANCE RELATIVE TO PEROXIDASE SYSTEM ACTIVITIES

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Extracellular peroxidase may serve a number of functions ranging from disease resistance to the regulation of growth. At least two peroxidase isoenzymes are found in plant cell walls. One isoenzyme requires the presence of NADH which is supplied by malate dehydrogenase (MDH). MDH is reported to be covalently linked to the wall. We found that expanding leaves of the commercial variety CP 70-321 contained both soluble peroxidase and MDH. Another soluble cell wall enzyme, glutamate oxaloacetate transaminase (GOT), was also detected. In accordance with

its proposed role in dicarboxylate transport and in maintaining the oxidation of malate by MDH which generates NADH, we propose that GOT helps maintain low levels of exaloacetate (OAA) in the wall. Low levels of OAA allow the continued production of NADH by MDH, whereas, high concentrations of OAA relative to malate stimulate the conversion of OAA to malate and the oxidation of NADH to NAD. By effectively increasing NADH, MDH and GOT increase growth can be associated with a decrease in peroxidase system enzymes, i.e; the activity of peroxidase.

Under certain conditions, gibberellic acid (GA) reportedly increases the growth and productivity of sugarcane. Our results indicated that the expanding leaves of isolated CP 70-321 spindles also responded well to GA_3. GA_3 promoted leaf growth within six hrs. This increase in leaf growth was associated with concomitant decreases in GOT, MDH, and peroxidase. Further increases in enzyme activities and growth were noted after 12 hr. Assuming that peroxidase normally decreases growth by catalyzing the cross-linking of cell wall polymers which stiffens the growth restraining wall, it is appropriate that an increase in peroxidase, MDH, and GOT was obtained.

Besides the association between GA, growth, and the peroxidase system, we detected a possible relationship between the peroxidase system and resistance to ratoon stunting disease (RSD). The isolated extracellular solution from the infected RSD resistant variety CP 52-68 caused approximately a two-fold increase in MDH compared to noninfected controls. Extracellular solution from the infected susceptible variety L 62-96 did not contain elevated levels of MDH. Preliminary experiments also indicated that there may be a relationship between the extracellular solution and bacterial growth.

RESPONSE OF SUGARCANE TO N, P, AND K FERTILIZATION IN SOUTH TEXAS

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Proper fertilization is an important management function in sugarcane production. Previous studies have defined the N fertilizer requirement for sugarcane grown in the Lower Rio Grande Valley of Texas (LRGV). Limited studies have been conducted regarding available soil P levels and sugarcane response to P fertilizer. No K studies on sugarcane have been conducted in the LRGV, since studies with other crops failed to show a response to K applications. Moreover, the type of clay minerals present in the LRGV soils has a large capacity to supply K to plants and to replenish the soil K used by plants. However, as the growth period and K requirement of sugarcane is greater than that of other crops studied, the need for K fertilizer by sugarcane in the LRGV has it advocates. This study was designed to determine: 1) the effect of N, P, and K fertilizers on cane and sugar yields, and juice quality, 2) the influence of cane age and NPK fertilization on leaf nutrient content, and 3) the relationship between yield and the leaf nutrient NPK content.

Sugarcane cultivar CP 65-357 was grown at four levels of N, three levels of P and two levels of K in a randomized split-split plot design with four replications. Each sub-subplot (N levels) consisted of six 30.5 m long rows of cane spaced 1.68 m apart.

Significant increases in cane and sugar yields were obtained from the application of N fertilizer. The application of P and K did not affect yields. The mean cane yields for all P and K treatments at the O, 67, 134, and 201 kg ha^{-1}, N rates were 44.4, 77.3, 83.1, and 87.1 Mg ha^{-1}, respectively. Corresponding sugar yields were 6.25, 10.5, 10.9, and 11.3 Mg ha^{-1}. Nitrogen fertilization significantly decreased Brix, pol, and purity of the normal juice. However, the reduction in sugar content was not enough to affect sugar yields. Juice K concentration increased from 0.38 to 0.51 percent as N fertilizer rates increased from 0 to 201 kg ha^{-1}.

Increasing the supply of N or P influenced the concentration in the leaves of both the applied nutrients and other nutrients. Whereas increasing the K supply did not significantly affect the K concentration in the leaves or juice. Mean leaf K values were in the normal range (1.3 - 1.6 percent) in early June but slightly deficient in August (1.0 to 1.2 percent). Cane yields were strongly correlated with leaf N and P concentrations. Critical leaf P percentage in early June was 0.22 percent, but changed as the crop matured. High soil levels of available K (155 ppm) and P (9.5 ppm) account for the lack of crop response to application of K and P fertilizer.

A TECHNIQUE FOR INFESTING SUGARCANE WITH SUGARCANE BORER, *DIATRAEA SACCHARALIS* (F.)

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A technique of disseminating first-instar larvae of the sugarcane borer, *Diatraea saccharalis* (F.), was evaluated both in the field and in the greenhouse. The technique involves mechanically dispensing a given number of laboratory reared larvae mixed with corn cob grits into the whorl of a sugarcane plant. This technique was evaluated for the uniformity of incidence of infestation.

Uniformity was measured in comparisons involving three commercial varieties in three field experiments and in a greenhouse experiment with 72 replications. In the field experiments, the susceptible variety CP 74-383 had a mean and 95 percent confidence interval of 65.9 $\pm$ 8.3 percent bored internodes, while the two resistant varieties CP 65-357 and CP 70-321 had 46.9 $\pm$ 7.2 and 46.9 $\pm$ 5.9 percent bored internodes, respectively. In a greenhouse test, CP 74-383 had 87.5 $\pm$ 3.8 percent "deadhearts", while CP 65-357 and CP 70-321 had 68.8 $\pm$ 6.6 and 67.1 $\pm$ 6.2 percent "deadhearts", respectively. This technique will be applied to evaluate sugarcane breeding lines for their relative levels of resistance to the sugarcane borer.

"C" MASSECUITE BOILING SYSTEM USING MICROPROCESSOR FOR NUCLEATION BASED ON BOILING POINT RISE SUPER-SATURATION CONTROL

Guillermo L. Aleman
Sugar Cane Growers Cooperative of Florida
Belle Glade, Florida

This paper deals with a complete system for the boiling of "C" massecuites beginning with graining up by Full Pan Seeding using Fundant-Isopropilic slurry for establishing nucleation and controlling supersaturation by Boiling Point Rise with a microprocessor.

ATLANTIC SUGAR COMPUTER UPGRADING AND EXPANSION PROGRAM

Jose F. Alvarez
Atlantic Sugar Association, Belle Glade, Florida

Atlantic Sugar Association is an Agricultural Cooperative which operates a 12,000 ton-per-day sugar factory in the vicinity of Belle Glade, Florida.

The factory has recently completed the first phase of its computer upgrading and expansion program, which consists of the installation of an IBM System 36 in the Main Office, and IBM-PC's or PC-XT's at the Truck Scales, the Agricultural Office and the Factory Laboratory.

The PC at the Truck Scales receives digital signals for each truckload directly from load cells and transmitters (Toledo), and these are simultaneously printed and input into the computer. Truck and trailer tares are in memory and are brought out for calculation of net weight of the load. This information is added to by the scale operator, who keys in Field No., Ticket No. and other important items.

Analytical data are generated in the Laboratory and subsequently merged with the above, together with information from the Agricultural Office. This information is used on-line for monitoring performance and decision-making, and subsequently for generation of reports.

LOW GRADE CRYSTALLIZER PERFORMANCE

S. Clarke, W. Keenliside, L. Serebrinsky
Audubon Sugar Institute
Louisiana State University, Baton Rouge, Louisiana

During the 1983 and 1984 Louisiana seasons, the flow and purity drop characteristics of the low grade crystallizers and the reheating and centrifugation of the massecuites were studied. Flow measurements were made at three mills and the measured retention time was in fair agreement with the calculated time. The time/temperature/brix/purity relationships were determined at seven mills and showed considerable variation from day to day and between mills. The reheating and centrifugation practices were surveyed at all the Louisiana mills; the molasses purity changes varied from negligible to a serious increase. These tests can demonstrate the inadequacies of the system, e.g., erratic operation, insufficient time or cooling, high massecuite purities, excessive reheating, etc. The test results and guidelines of optimizing crystallizer operation will be presented.

MICROCOMPUTER PROGRAM TO CALCULATE EFFICIENCY OF SUGAR MILL BOILERS

J. A. Fajet
Talisman Sugar Corporation, Belle Glade, Florida

This computer program was developed to calculate the efficiency in boilers using bagasse as fuel. Calculations are based on actual fuel and boiler performance data. The program is written in BASIC. Computer used was a Hewlett-Packard Model 86.

Program inputs are fuel data, ultimate analysis, moisture and heating value of bagasse. Actual boiler performance data is temperature of combustion air, temperature of gases leaving boiler and Orsat analysis of fuel gases.

Perfect combustion calculations for the given fuel are executed first, then excess air combustion calculations for up to 150 percent are done and the actual excess air used is determined based on the Orsat analysis. Then the program proceeds to calculate all boiler losses and the efficiency from the results of the combustion balance and the performance data. Incomplete combustion and unburned fuel losses are included.

Finally a printout can be made of all inputs and outputs for record or reference purposes.

SPECIFICATION FOR BAGASSE ASH ASPHALT COMPOSITION

Glenn A. Hirsch
Corps of Engineers, U. S. Army Engineer District
New Orleans, Louisiana

A method of composition is disclosed which is particularly suitable for forming a bituminus paving mixture. This method covers the determination of that portion of the mineral in asphaltic mixtures which pass on a 75 um (no. 200) sieve. More specifically, the present invention relates to the composition comprising a non-newtonian fluid, petroleum emulsified asphalt combined with a selected filler called Bagasse Ash. The invention utilizes a by-product of the sugarcane industry, bagasse ash obtained by burning bagasse from the extraction of sugarcane, and thus sifting and grinding the ash to a preferred particle size. Bagasse ash is preferred Pozzolanic material, asphalt emulsion cofiller. Preferably the Bagasse Ash is batched directly with petroleum asphalt emulsion and selected fillers and aggregates during manufacture, in and amount by weight, of at least 21 to 28 percent.

EVAPORATOR BOIL-OUT

Gary Lee, Ed Habyeb
Betz Laboratories, Inc., Trevose, Pennsylvania

Current status of progress to improve Boil-Out procedures with a single component program is presented. With this approach, it is expected that a sugar mill can reduce downtime, minimize metal attack, and achieve cost savings.

ELBOW FLOW ELEMENT IN THE SUGAR INDUSTRY

J. J. Mecsery, Antonio Guillen, and Antonio Arvesu
Czarnikow-Rionda Engineering, Inc.
Glades Sugar House, Sugar Cane Growers Cooperative of Florida

The presentation will discuss basic design, when or why to use an elbow flow element, advantages and disadvantages, where used in the sugar industry, actual installation, curves and formulas to design an elbow flow element, element location and recommended straight pipe, construction tips, and the program to be used with a HP-41C Hewlett Packard Programmable Calculator.

AN INVESTIGATION OF MILL SETTINGS IN SUGARCANE CRUSHING TRAINS

G. D. Whitehouse
Mechanical Engineering Department
Louisiana State University, Baton Rouge, Louisiana and

Charles Patterson
Sandia Corporation, Albuquerque, New Mexico

The mechanical parameters in the standard three roll sugar mill were examined. The investigation was made both experimentally and by use of mathematical model founded on research done in Australia. The model was used in conjunction with a non-linear search algorithm to calculate the most efficient mill clearances predicted by the model. These results were compared with the results of other mill setting techniques. The results showed that the use of the mathematical model coupled with the non-linear optimization routine produced viable mill setting predictions. This computer method could be useful in simulating the mechanical parameters involved in milling trains.

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Papers submitted must represent a significant technological or scientific contribution. Papers will be limited to the production and processing of sugarcane, or to subjects logically related. Authors may submit papers that represent a review, a new approach to field or factory problems, or new knowledge gained through experimentation. Papers promoting machinery or commercial products will not be acceptable.

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RULES FOR PREPARING PAPERS TO BE PRINTED IN THE
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Format

Unless the nature of the manuscript prevents, it should include the folloing sections in the order listed: ABSTRACT, INTRODUCTION, MATERIALS and METHODS, RESULTS, DISCUSSION, CONCLUSIONS, ACKNOWLEDGMENTS, and REFERENCES. Not all the sections listed above will be included in each paper, but each section should have an appropriate heading that is centered on the page with all letters capitalized.

Authorship

Name of the author(s), institution or organization with which he is associated, and the location should follow the title of the paper.

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The abstract should be placed at the beginning of the manuscript, immediately following the author's name, organization and location.

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Number the tables consecutively and refer to them in the text as Table 1, Table 2, etc. Each table must have a heading or caption. Capitalize only the initial word and proper names in table headings. Headings and text of tables should be single spaced. Each table should be on a separate sheet.

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Suggested Format (Examples below)

EVALUATION OF SUGARCANE CHARACTERISTICS
FOR MECHANICAL HARVESTING IN FLORIDA

J. E. Clayton and B. R. Eiland
Agricultural Engineers, SEA, USDA, Belle Glade, Florida

J. D. Miller and P. Tai
Research Geneticists, SEA, USDA, and Canal Point, Florida

ABSTRACT

INTRODUCTION

MATERIALS and METHODS

RESULTS

Table 1. Varietal characteristics of nine varieties of sugarcane over three-year period at Belle Glade, Florida.

Figure 1. Relative size of membrance pores.

DISCUSSION

CONCLUSIONS

ACKNOWLEDGMENTS

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ASSCT

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PRESIDENT'S MESSAGE - FLORIDA DIVISION

Jose F. Alvarez
Atlantic Sugar Association
Belle Glade, Florida

It is an honor to have been elected President of the Florida Division of the American Society of Sugar Cane Technologists. At the upcoming 16th Annual Joint Meeting of the Louisiana and Florida divisions of this society, we will continue, in unison, to find solutions to our common problems and once again highlight our motto to help the mainland sugarcane industry.

This spirit of cooperation and willingness to share our good and bad times gives this meeting a special meaning and a sense of pride which I sincerely share.

In my short experience in this industry, I am not followed by the dedication and the many years of service that some of you have given to this industry. Many of you have a lifetime of service, commitment, and steadfastness that is exemplary, and I admire these qualities. These same qualities make this industry unique, not only in the United States, but in the world.

The seven mills in Florida have just completed a successful campaign in which more than 13 million tons of sugarcane were harvested and processed to produce 1,413,000 tons of sugar and 93 million gallons of molasses. This surpasses Florida's previous record, set in the 1984/85 crop, of 1,412,000 tons. The Florida sugar industry is proud of the success it has had in the last few years, becoming the number one state in the production of sugar.

Competition in the national market continues at a frantic pace. The artificial sweeteners have not, for one second, failed to bombard the consumers with the bad attributes of sugar and, of course, they have gone as far as insinuating that their product is "almost" natural. Corn syrups have not gone away; they have deeply penetrated the soft drink market. Experts predict that they have reached maximum penetration. In short, sugar's traditional market has eroded over the last five years by approximately 21 percent. Consumption of refined sugar now stands at 7,500,000 short tons. In 1980, the consumption of refined sugar was 9,520,000 short tons, and in 1985 the consumption was 7,580,000 short tons.

As a famous industrialist once said, "Problems are opportunities in workclothes." That being the case, we will face a lot of "opportunities" in the next few years. The sugar industry stands, along with other industries, at the crossroads of a technological revolution which has been called "high-tech." For our industry to survive in the United States, we have to embrace this technological revolution and apply it creatively to the problems that we face now and may face in the near and distant future. We must look for more efficient ways of harvesting, processing, handling, and marketing our products. This society of technologists can play a vital role in bringing about the creative talents and resources that could coalesce into solutions that will guarantee the survival of the sugar industry.

An article in the April issue of Food Engineering entitled "Tomorrow's Technology," exposes several technologies which, through creative applications, have found a permanent place in the food industry. Laboratory robots are increasing productivity in laboratories and increasing efficiency in quality control; machine vision is making the inspection of products faster and more accurate; supercutical extractions are believed to have vast potential. Food irradiation, computer integrated manufacturing, microwaves and flow injection analysis are just a few of the technologies that are beginning to have an impact in the food industry.

The application of new technology to the problems of the sugar industry is a continuous process that takes research, development, and total commitment. It is a process that may require us to do things a little differently and to look at problems from a different perspective. It is a process that is essential in order for the sugar industry to remain viable and competitive.

There are many instances of new application of technologies that have been implemented in the sugar industry in the last few years, and some of them will be presented in several papers outlined at the 16th Annual Meeting. I am not suggesting that we have ignored the technological advances that are now available, but our challenge, as a society of technologists and engineers, is to step up this process.

We can be effective in bringing about the changes needed in the sugar industry. The challenge is not only the application of new technology to our processes, it goes beyond. Political, natural environment, marketing, and human resources cannot be ignored. The latter requires special attention since it is the most valuable and essential resource. The management of human resources is just as important as the management of crops, mills, and marketing. Our tendency has been to concentrate on other processes.

The sugar industry's challenge is to be productive, efficient and innovative, and this requires attention to the industry's total environment.

Some other basic manufacturing industries, such as steel, automobile, and fabric manufacturing, have already felt the sting of foreign competition and have been forced to innovate or perish. The sugar industry is not any different. Our problem is not so much foreign competition, but the parallel of survival cannot be ignored.

We can continue to live up to our motto to <u>help the mainland sugar industry</u>, but only in a more dynamic and significant way.

PRESIDENT'S MESSAGE - LOUISIANA DIVISION

Daniel P. Viator
Triple V Farm
Youngsville, Louisiana

On behalf of the Louisiana Division of the American Society of Sugar Cane Technologists (ASSCT), I would like to express a sincere appreciation to the Florida Division for hosting this 16th annual joint conference in Clearwater, Florida.

The 1985 sugarcane crop year in Louisiana could best be described as very difficult and extremely challenging, both mentally and physically. The industry had not even had time to forget the disastrous freezing temperatures of December 24-26, 1983, when history repeated itself. On January 21 and 22, 1985, temperatures again dropped to 13° F at the USDA Station in Houma. Low temperatures did not last as long as in the previous year, and with the increase in plant cane acreage, growers were hopeful that the yields would be better than 1984's low yields.

Another natural disaster - Hurricane Danny - occurred in the Louisiana cane belt on August 15. Although it was classified as a minimal hurricane, it caused considerable damage primarily in the western fringes of the cane belt. In these areas, as much as 60 percent of all varieties had top breakage. On August 30, Hurricane Elena was taking dead aim at New Orleans and much of the cane belt. Initially, a last minute turn to the east spared Louisiana, but after damaging the Florida coast for two days, Elena turned around and traveled northwest - entering the coast near Biloxi, Mississippi. It missed the cane belt by less than 100 miles.

Finally, in mid-October, the industry began its harvesting season with hopes for a relatively easy grinding season. These dreams quickly disappeared when Hurricane Juan began circling over the sugar belt October 26-30 and dumped as much as 12 inches of rain. Although winds did not exceed 40 or 50 mph, fields were soaked enough to cause severe lodging. This was the third hurricane to pass near the sugarcane crop in 1985, and it was the first hurricane on record to hit during the harvest season. The wet fields forced most of the Louisiana mills to close for a few days, with several mills staying closed for up to seven days.

Despite two years of record low temperatures and three hurricanes during the growing season, production was outstanding. Acreage for milling increased from 205,000 acres in 1984 to 230,000 acres in 1985, an increase of 12.2 percent. The total 1985 sugar production was 530,667 tons versus 455,000 tons in 1984 - an increase of 16.6 percent in total sugar. Average sugar per acre increased from 4,439 pounds in 1984 to 4,614 pounds in 1985 - a 3.9 percent increase.

The 1986 crop looks promising since there have been no hard freezes on the crop. There is also a higher percentage of the crop consisting of plant cane and first stubble due to heavier plantings for the past two years because of the severe freezes in 1984 and 1985. The 1986 crop has the potential to become a bumper crop.

The 1985 price for sugar was less than expected, as sugar prices stayed substantially below the Market Stabilization Price for much of the year. These lower prices were caused mostly by President Reagan's decision to increase foreign import quotas. As a result, for the first time under the Sugar Program, domestic sugar was forfeited to the Commodity Credit Corporation.

Last year was also very important in determining the economic future of sugarcane in the U.S., as evidenced by the extensive debate and final passage of the five-year Farm Bill. With the "free" market philosophy concept being promoted by the Reagan Administration, it was apparent that the industry faced an uphill battle to convince Congress that a "free" market for sugar does not exist throughout the world. Most countries practice some sort of market intervention to protect their respective domestic sugar markets. Therefore, the U.S. sugar industry has to compete against countries where sugar industries are heavily subsidized.

Our lawmakers, despite many long and exhaustive battles, enacted sugar legislation in the 1985 Farm Bill that will allow the industry to survive and maintain for the consumers a stable and fair price for sugar. The bill provides a non-recourse loan program for sugar at a price of 18 cents per pound for five years, beginning with the 1986 crop. There is also a provision in the bill requiring that the program be operated at no cost to the government. Considering the political and economic climate, the industry is indeed fortunate to have won passage of this bill. The

current program will not guarantee anyone a profit, but it will allow the efficient producer a fair return. President Reagan, however, has been openly critical of the Sugar Section of the Farm Bill and has vowed to change it. With these threats and the enactment of the Gramm-Rudman Bill, we must constantly be on guard so that these minimum price support levels are maintained.

The industry is fortunate to have support and help from our congressional delegation, lobbyists, research personnel at the USDA and LSU, the American Sugarcane League, and the Cooperative Extension Service. These groups of people have helped make sugarcane farming in Louisiana successful for over 150 years. However, with time, things change. We must be prepared to adapt to these changes in order to be as successful as our forefathers were. We can no longer be familiar with production and manufacture; we must also become involved in making decisions regarding research, politcal, and market advertisement.

The Louisiana sugarcane industry is a close knit family. With a continuation of the courage and spirit of cooperation that has existed in the past, it is my hope that the domestic sugar industry will continue to survive the challenges.

ABUNDANCE OF FORAGING ANT PREDATORS OF THE SUGARCANE BORER IN RELATION TO SOIL AND OTHER FACTORS

W. H. Long, L. D. Nelson, P. J. Templet and C. P. Viator
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Department of Biological Sciences
Nicholls State University, Thibodaux, Louisiana 70310

ABSTRACT

Extensive, weekly, summer surveys of sugarcane borer (SCB), Diatraea saccharalis (F), infestations and collections of predatory arthropods were made in 80 different sugarcane fields on as many different farms in eight sugar-producing parishes of Louisiana during 1982-83. Soil from each field was analyzed for various chemical properties and textural characteristics. An additional spring survey of cane fields in 12 Louisiana parishes was conducted during May 1984 for ants only.

The red imported fire ant (RIFA), Solenopsis invicta Buren, occurs more abundantly in fields of fine textured clay soils than in those of coarser textured loam soils. This significant find explains why SCBs have long been known to cause less crop stress in south Louisiana fields of heavy clay soil than in fields of coarser textured soils.

More than 98% of all predaceous arthropods collected on cane plants during two summers were ants. Ants were found foraging actively in all kinds of summer weather, at all times of day and at night.

The RIFA has increased in Louisiana cane fields from a subdominant species in 1960 to a position of undisputed dominance today, and in the process has replaced the once dominant argentine ant, Iridomyrmex humilis (Mayr). The RIFA now easily accounts for more than 90% of the cane field ant fauna in Louisiana.

The need for insecticide treatment to control the SCB decreases with increasing abundance of foraging ants in cane fields. The insecticides, Azodrin (monocrotophos) and Guthion (azinphos-methyl), have no significant effects on the abundance of foraging predatory ants when used on the farm to control SCBs in sugarcane.

INTRODUCTION

For many years the presence of ants in sugarcane fields was considered to be unimportant (23), or even harmful (3,9,10,25). The latter idea may still persist and be valid in some places under some conditions. Early workers (before 1940) had reported predation by ants on immature stages of the SCB (20,27). In 1951 Ingram et al (11), working in Louisiana, stated that the value of ants in SCB control was more than offset by the increase in mealybugs and aphids which they caused. Apparently ants in Louisiana cane fields were believed to be either unimportant or somewhat detrimental.

However, in 1958 Long et al (14) reported drastic increases of SCB populations and associated damage in cane fields treated with heptachlor to eradicate the RIFA. At this time, the RIFA was not the only ant species present in those fields, and it had not yet become the most abundant ant species there. These observations prompted new research on the role of ants in sugarcane fields.

Hensley et al (7) published data on the catastrophic increases in SCB numbers and associated crop damage which occurred in cane fields treated with heptachlor to eradicate the RIFA. They cited numbers of predatory arthropods collected in pit-traps from other insecticide-treated and untreated plots. They compiled a long list of arthropod predators from cane fields among which beetles, ants, and spiders were most prominent.

A series of studies followed using the pit-trap to collect arthropod predators from insecticide-treated and untreated plots (15,16,17,18,22). The major conclusions reached were that spiders, predatory beetles, and ants, particularly the latter, are all beneficial in the natural control of the SCB, and that any insecticide application which significantly reduces the numbers of these predators should be expected to increase problems from the SCB.

In Florida cane fields, Adams et al (1) obtained quantitative population data for four ant species using honey-agar and meat bait stations placed on the ground.

They calculated correlation coefficients between numbers of ants and SCBs, and concluded that the reduction of all ant species by mirex bait in some fields resulted in increased damage from the SCB.

Much of the evidence supporting the concept that predatory ants are the most important biological agents in the natural control of the SCB is of a correlative type. However, Negm and Hensley (17,18) published records of field observations of predation by the RIFA on all immature stages of the SCB and by other predators on various SCB stages. The senior author of this paper, on rare occasions over the years, has observed ants attacking SCBs in the field. However, much time and patience generally is required to observe this.

Carroll (4) collected ants in Florida sugarcane fields by hand and with pitfall traps. He reported 28 species of ants in Florida cane fields, 23 of which were found foraging on the cane plants. Fifteen ant species were found attacking SCB eggs, while 13 killed first instar larvae. Pheidole dentata Mayr, and P. floridana Emery were reported to be the most avid feeders on SCBs. However, he indicated that, at that time, RIFAs were reaching Glades County and south Florida sugarcane fields for the first time.

Ali et al (2) departed from the pit-trap technique. They used aspirators or forceps to collect foraging RIFAs returning to the mound with food. They found that more frequent foraging occurred in grassy than in weed-free sugarcane habitats. They reported a great variety of food items intercepted, of which 4.74% were lepidopterous larvae. They concluded that RIFA population levels could be enhanced through judicious vegetation management which would result in greater ecological stability of the sugarcane ecosystem.

White (24) indicated that predation increases with the age of the sugarcane crop. He found less predation of SCBs in the plant cane crop than in the 1st ratoon crop, and less in the latter than in 2nd ratoon cane. He also found a greater frequency and proportion of abandoned RIFA mounds in weed-free plots than in weedy plots. This was not due to herbicides since weeds were controlled by hand.

Many factors may influence the abundance of SCBs in the field. Some of these are known and are utilized in a sugarcane insect pest management program which takes advantage of the suppressive effects of arthropod predators, varietal resistance, and weather conditions, and utilizes insecticides only as a last resort (6,12,21).

The objectives of the studies reported in this paper were: 1) to determine how the abundance of foraging ants is related to SCB infestation and the need for insecticide applications to control the SCB; 2) to monitor the effects of insecticide applications in the field on the abundance of foraging ants; 3) to determine how the species composition of the cane field ant fauna has changed in Louisiana since 1960; 4) to determine how time of day and weather conditions affect the abundance of foraging ants; and 5) to study the relationships between the chemical and textural characteristics of soil and the abundance of ants foraging in Louisiana cane fields.

MATERIALS AND METHODS

Eight weekly collections of predatory arthropods and determinations of SCB infestation were made from late June through mid-August in each of 80 sugarcane fields on as many different farms in eight sugar-producing parishes of south Louisiana. All fields were first year stubble (ratoon) of the variety CP 65-357. Collections and determinations from 40 fields were made in 1982 and from the remaining 40 in 1983.

The weekly collection from each field consisted of a 5-minute search by one person, who collected predaceous arthropods by aspirator and by hand from sugarcane plants. Collected specimens were placed in jars of alcohol for later counting and identification in the laboratory. The jars were labeled for date, location, time of day, prevailing weather conditions (clear, overcast, or rainy), and percent borer infestation.

On the same dates that predator collections were made, the percent of stalks infested with SCBs was estimated in each field by examining 25 stalks for the presence of young SCB larvae in or behind the plant leaf sheaths and not yet bored into the stalks. The 25 stalks examined were 2 paces apart, located on one or two rows near the middle of each field and at least 10 paces from the field border (drainage ditch or field road). Recommendations for spraying to control the SCB were made as needed, and records were kept of the dates of all insecticide applications.

Soil samples were taken from each of the 80 fields and sent to A & L Agricultural Laboratories in Memphis Tennessee, for analysis. Analyses were made for percentages of organic matter, sand, silt and clay, for parts per million (ppm) of phosphorus (by both weak and strong Bray methods), potassium, magnesium and calcium, and for soil pH and cation exchange capacity (CEC).

An additional spring survey of 100 sugarcane fields in 12 Louisiana parishes was conducted during May 1984 for ants only. This survey was made during the same month and in approximately the same way as a survey made 24 years earlier (13). Two people collected by aspirator all the ants they could find during five minutes in each field. Fields were selected systematically and were several miles apart in each parish to insure that the survey would be representative of the Louisiana sugarcane area. Collected ants were later counted and identified in the laboratory.

RESULTS AND DISCUSSION

When the 80 sample fields were grouped according to the numbers of insecticide applications required in each for SCB control, it was found that the largest numbers of ants were collected in those fields which required no insecticide for SCB control (Figure 1). As the number of insecticide applications required increased from zero to four, the average numbers of ants collected per field decreased from 140 to 3, respectively. Differences among these means are significant by analysis of variance with $F = 7.12$, $df = 4$ and 75, and $P<.01$. In other words, less insecticide was needed to control the SCB in those fields where more ants were present.

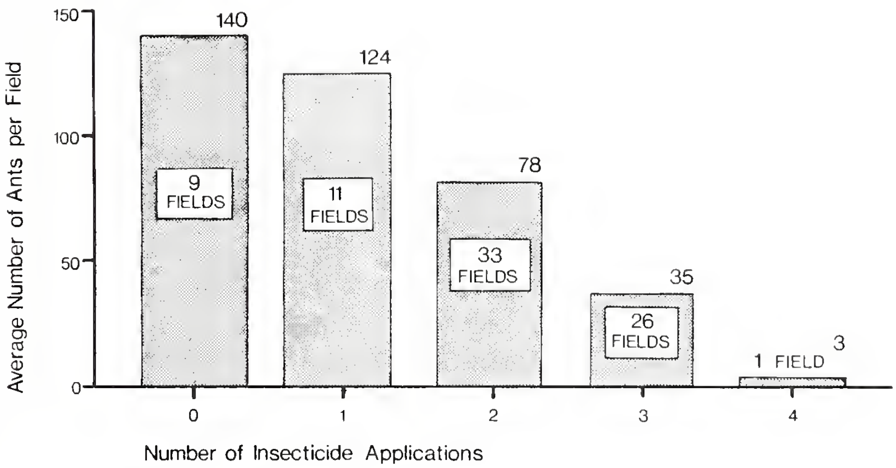

Figure 1. Average numbers of ants collected in fields requiring different numbers of insecticide applications for control of the sugarcane borer, 1982-83.

There was no indication that these differences in foraging ant abundance among the sampled fields had been affected by insecticides applied to control the SCB. When numbers of ants collected during the 2-week intervals before and after first insecticide application were compared, there was no significant difference between them. In fact, an average of only 3.4% fewer ants were collected following the first Azodrin treatment in 51 fields than before the treatment, while 8.7% more ants were collected following the first Guthion treatment in 14 fields than before the treatment. For both insecticides together in 65 fields, the difference between pre- and post-treatment ant abundance was less than 1%.

This does not mean that these insecticides do not kill ants. Indeed, dead ants are commonly found on cane plants following treatment with either insecticide. However, since most ants of a colony are in the nest at any particular time, and since insecticide residues begin to dissipate following their application, it is not surprising that the mortality observed does not significantly affect the abundance of ants foraging during the 2-week period following treatment.

In the survey of ants in Louisiana cane fields made in the spring of 1960 (13), 11 species were identified. The four most abundant, ranked according to decreasing abundance, were I. humilis, RIFA, Pheidole dentata Mayr, and Paratrechina melanderi Whlr. (Figure 2). These four species collectively accounted for 95% of Louisiana cane field ant fauna at that time. Of these four, I. humilis, the most abundant, probably already had begun to yield to pressures from increasing populations of the RIFA, which is believed to have entered south Louisiana between 1949 and 1953 (5). According to Wojcik (26), scattered, incipient infestations, known to exist in Louisiana in 1950, grew and coalesced until most of the state was infested by 1962.

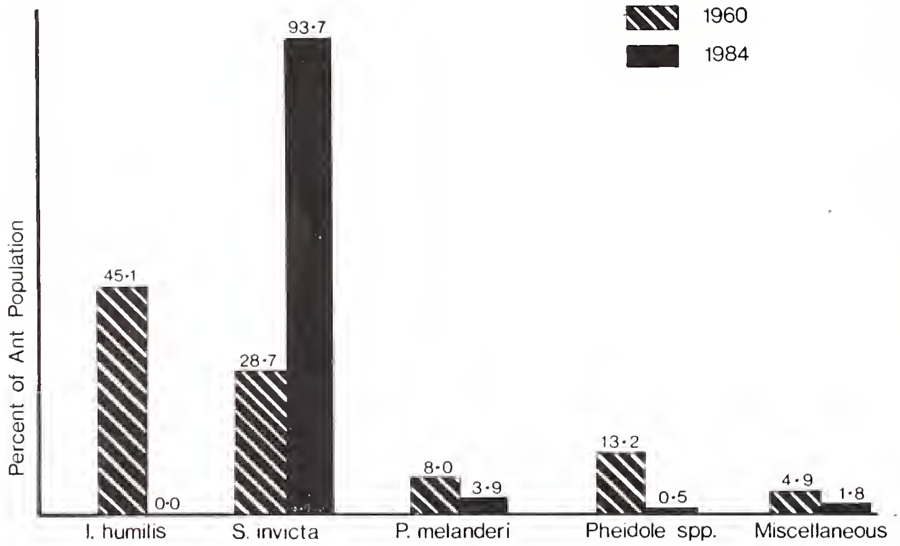

Figure 2. Relative abundance of ant species collected in Louisiana sugarcane fields in 1960 and 1984.

By 1984, the RIFA had increased to make up almost 94% of the Louisiana cane field ant fauna (Figure 2). This is based on results from the spring survey conducted in May 1984 in which a total of 1,470 ants were collected from 100 fields in 12 Louisiana parishes. During the summer collections of 1982-83, a total of 6,154 ants were caught, of which 91.5% were RIFAs. These data indicate that the RIFA now accounts for more than 90% of Louisiana's cane field ant fauna. Indeed it likely reached this level of relative abundance several years earlier, although no previous attempts were made since 1960 to document this.

It is interesting to note that the argentine ant, I. humilis, was not found at all in the 1984 spring ant survey (Figure 2), nor was it found in the summer collections of 1982-83. This was the most abundant ant present in 1960 (13), when the application of heptachlor to some cane fields for eradication of the RIFA resulted in dramatic increases in SCB populations (14). These observations suggest that, although the RIFA has now become the dominant species and I. humilis apparently has disappeared from Louisiana cane fields, the earlier complex of I. humilis and other ants constituted a significant force in the natural control of the SCB. I. humilis still occurs in south Louisiana. The senior author collected it in July 1985 from a parking lot in Donaldsonville, Louisiana.

The cane field ant fauna in Louisiana is dominated today by a single species, the RIFA, and is obviously less diverse than it was in 1960 (Figure 2). Although Adams et al (1) working in Florida, have suggested that a multiple predator ant complex is more effective than one dominated by the RIFA, we do not believe that this is necessarily true, particularly with a species as aggressive, abundant, and territorially tenacious as the RIFA.

More than 98% of all predaceous arthropods collected during two summers, 1982-83, were ants. This relative abundance of ants found on plants emphasizes their importance as a factor in the natural control of the SCB, since predators must forage on plants to find SCBs. Previous studies in which quantitative data were obtained on numbers of arthropod predators in cane fields have emphasized the use of pit-traps which catch organisms running about on the ground, many of which may never encounter a SCB (7,15,16,17,18,22).

The abundance of ants foraging at different times of day during the 1982-83 collections differed little during daylight hours between 7 a.m. and 7 p.m. ranging from 100 to 122 ants collected per man-hour. Additional cane field ant collections made during spring and summer months of 1984 between 10 p.m. and midnight, using both aspirators and bait traps, indicate that ants are foraging actively at night also. Ants also were actively foraging under all weather conditions during the summer, but were on the average less abundant during rainy weather than when skies were clear or overcast. Average numbers of ants collected per man-hour ranged from 75 in rainy weather to 108 when skies were overcast to 123 under clear skies.

Coefficients of linear regression were calculated for numbers of RIFAs on the various soil chemical and textural characteristics studied. Tables 1 and 2 show which of these calculated regression coefficients were statistically significant.

Table 1. Statistical significance of coefficients of regression of ants on soil chemical characteristics.

Soil Characteristics	F - Values		
	Calculated	P = .05	P = .01
Phosphorus (weak bray)	0.40	3.96	6.97
Phosphorus (strong bray)	1.08	3.96	6.97
Potassium	1.62	3.96	6.97
Magnesium	3.78	3.96	6.97
Calcium	7.21**	3.96	6.97
pH	0.01	3.96	6.97

**Significant at 1% level.

Table 2. Statistical significance of coefficients of regression of ants on soil textural characteristics.

Soil Characteristics	F - Values		
	Calculated	P = .05	P = .01
Cation Exchange Capacity	3.69	3.96	6.97
% Sand	0.001	3.96	6.97
% Silt	5.71*	3.96	6.97
% Clay	3.45	3.96	6.97
% Organic Matter	0.83	3.96	6.97

*Significant at 5% level.

Among the soil chemical characteristics, a positive and significant regression coefficient was found only between RIFA numbers and soil calcium (Ca) levels (Table 1). The calculated regression formula indicates an average increase of 30 RIFAs per field collected during a summer for each increase of 1000 ppm of soil calcium (Figure 3). A positive relationship between RIFAs and magnesium (Mg) only approached significance at the 5% level (Table 1).

Among the soil textural characteristics, only % silt was significantly related to RIFA numbers (Table 2). The calculated regression formula indicates that the number of RIFAs collected per field during a summer decreased on the average by 14.2 ants for each 10% increase in silt content of the soil (Figure 4).

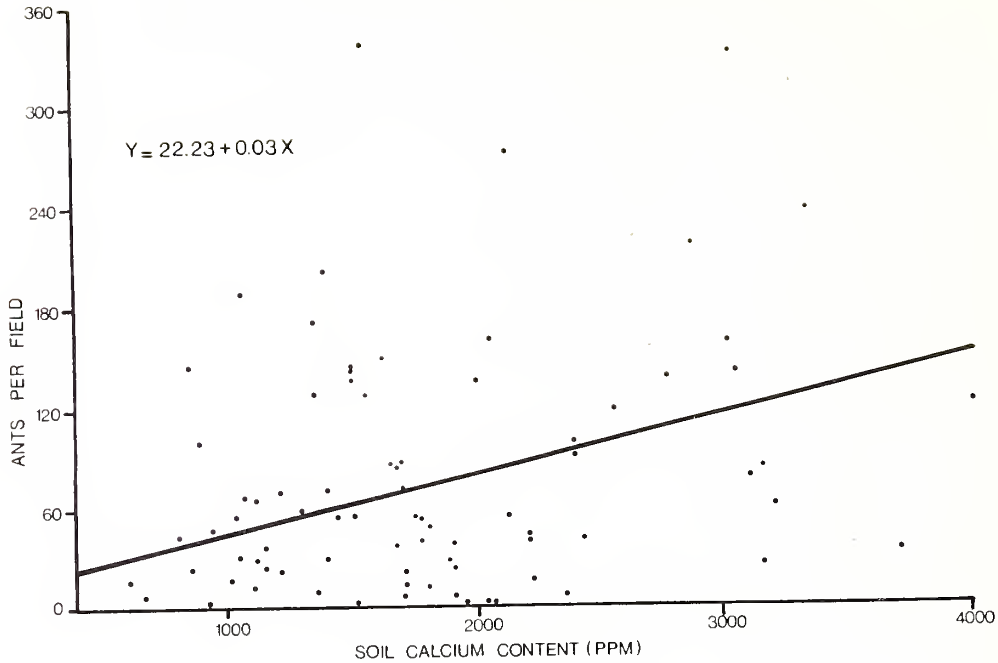

Figure 3. Numbers of S. invicta relative to soil calcium content.

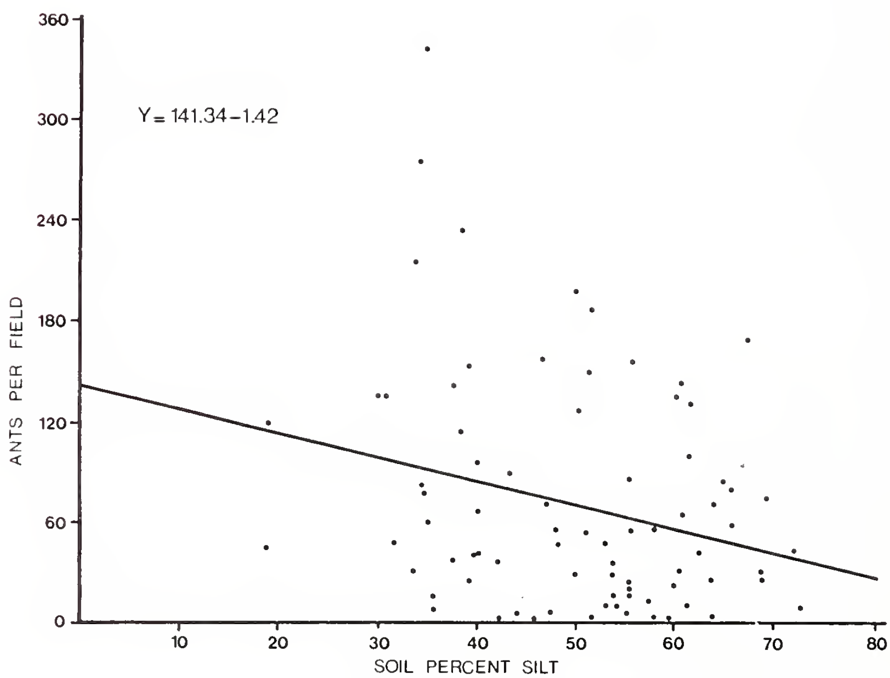

Figure 4. Numbers of S. invicta relative to soil silt content.

RIFA numbers decreased with increasing % silt in the soil (Figure 5); their numbers were greatest with maximum % clay (Figure 5) and with maximum CEC (Figure 6). Although ant abundance was not significantly related to % clay and CEC, it is not surprising that these relationships did approach statistical significance (Table 2).

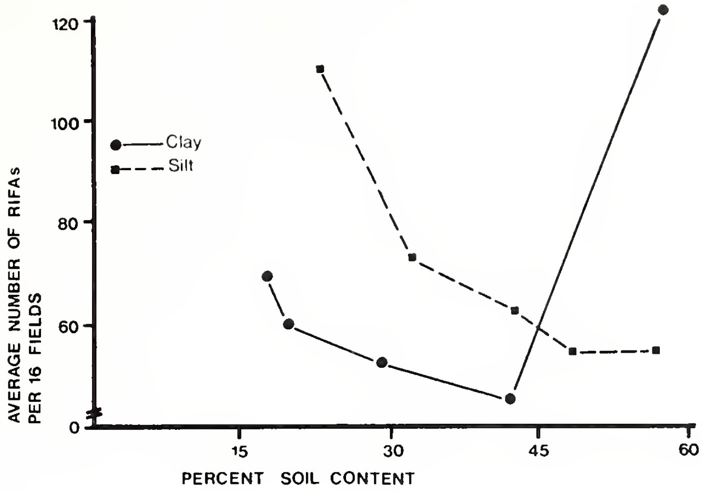

Figure 5. Numbers of S. invicta relative to soil content of clay and silt.

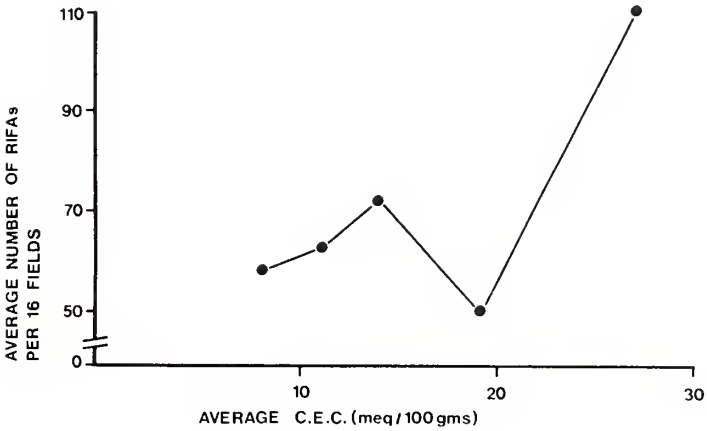

Figure 6. Numbers of S invicta relative to soil cation exchange capacity.

CEC is affected by soil texture and by % organic matter. It generally increases with increasing amounts of clay or organic matter. As % clay increases in soil, there must be an accompanying decrease in % silt or % sand or both. Therefore, the observed positive relationships between RIFA abundance and % clay and CEC are not surprising in view of the significant negative relationship between RIFA abundance and % silt.

For all 80 fields in which weekly collections were made during the summers of 1982-83, there were 64% more RIFAs in clay soils than in loam soils (Figure 7).

This difference is statistically significant by analysis of variance with F = 5.03, df = 1 and 78, and P = .02. This find largely explains why both farmers and researchers for many years have observed more SCBs in fields of coarser textured soils, which often are on the fronts of farms in south Louisiana, than in fields of heavier or finer textured soils.

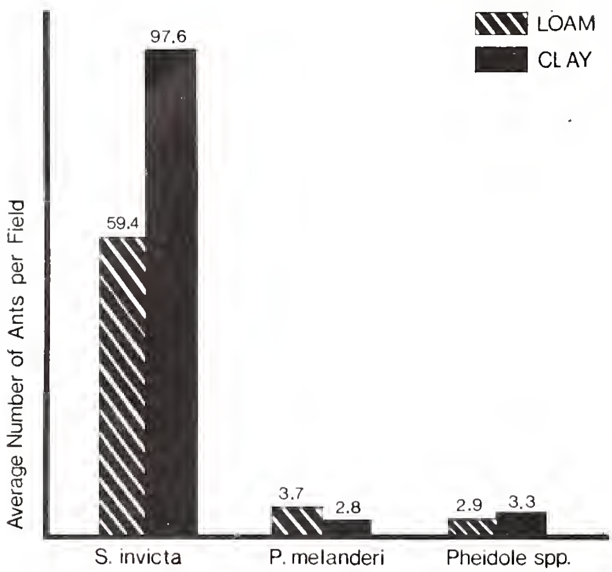

Figure 7. Relative abundance of ant species in clay and loam soils of south central Louisiana.

It is not known whether the greater abundance of RIFAs in clay soils is directly dependent on some relationship between the insect's biology and soil texture, or if it might be due to some other factor which only happens to be correlated with texture. For example, a higher water water table probably is more often associated with the clay than with the loam soils of south Louisiana.

Regarding soil texture as an ecological factor of importance to ants generally, Hess (8) found that clay soils support the largest number of ant species, while sands support the fewest. He reported a number of species which were cosmopolitan, one which seemed to favor sandy loams, and one (Solenopsis xyloni) which seemed to favor clays. In our studies, ant species, other than the RIFA, were not sufficiently abundant to permit conclusions about the effects of soil texture on their abundance.

The significant positive regression of RIFA numbers on soil Ca levels (Figure 3) and the near significance of a similar relationship with soil Mg (Table 1) may be only coincidental and not based upon any causal relationship. Clay soils with high CECs normally contain more Ca and Mg than do lighter textured soils with lower CECs.

CONCLUSIONS

From these studies, the following conclusions were reached. 1) The need for insecticide treatment to control the SCB decreases with increasing abundance of foraging predatory ants in cane fields. 2) The insecticides, Azodrin and Guthion, have no significant effects on the abundance of foraging ants when used on the farm to control SCBs in sugarcane. 3) Cane field ants are foraging actively in all kinds of summer weather and at all times of day as well as at night. 4) More than 98% of all predaceous arthropods collected on cane plants during two summers of extensive surveys were ants. 5) The RIFA has increased in Louisiana cane fields from a

subdominant species in 1960 to a position of undisputed dominance today, and in the process has replaced the once dominant argentine ant, I. humilis. 6) The RIFA now accounts for more than 90% of the cane field ant fauna in Louisiana. 7) RIFAs are more abundant in the fine textured clay soils of the Louisiana sugarcane growing region than in the coarser loam soils.

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EFFECTS OF SUBSURFACE DRAINING JEANERETTE SOIL ON CANE AND SUGAR YIELDS

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ABSTRACT

Subsurface drains were installed in Jeanerette (Typic Argiaquoll) soil in Iberia Parish, Louisiana, in 1978 to determine soil and crop response to subsurface drainage and to determine if crop production efficiency could be increased with subsurface drainage. Plastic drains which emptied into sumps equipped with electric pumps for discharging drain outflow into a surface drainage ditch were installed for the experiment. The 4-acre experimental site included three fields with four, three, and two drain lines spaced 45, 90, and 135 feet apart, respectively, and one field with no subsurface drainage.

Sugarcane was planted in the fall of 1979. The plant crop was harvested in December 1980 and the first and second ratoons were harvested in November 1981 and 1982, respectively.

Average annual rainfall for the area is 60 inches. Rainfall during the experiment was 66, 45, and 73 inches in 1980, 1981, and 1982, respectively, which was 10 percent above, 25 percent below and 22 percent above average, respectively.

Water tables were lowest in the fields with 45- and 90-foot drain spacings and highest in the nondrained field. Sugar yields indicated no advantage in spacing drains closer than 90 feet.

Sugar yield from the 45- and 90-foot drain spacing fields averaged 1500 lbs/A (33%) more than the nondrained field. The 135-foot drain spacing field yielded 843 lbs/A (20%) more than did the nondrained field. Subsurface drained sugarcane fields yielded 5.3 T/A (19%) more than the nondrained field. The increase in sugarcane yields was attributed to larger and heavier stalks from the subsurface drained fields. Plant population was similar for all fields.

Sugar yields on drained and nondrained fields differed more in ratoon crops than in the plant crop. If the differences were due to subsurface drainage alone, then drainage was more effective in boosting yields in ratoon crops.

The data showed a marked increase in crop production efficiency. Sugar yield data from the nondrained area showed that 500 acres of cane would be required to produce 1000 tons of sugar annually. For the subsurface drained areas, the same quantity of sugar could be produced on 366 acres - 25 percent less land. If the differences were due to subsurface drainage alone, subsurface drainage could result in considerable savings in operating costs for sugar production in Louisiana.

INTRODUCTION

Large amounts of precipitation on low lying, nearly level topography cause severe water table problems in the crop growing areas of the lower Mississippi Valley. Annual precipitation frequently exceeds 60 inches and monthly precipitation frequently exceeds 10 inches. Much of this precipitation runs off but the infiltration that does occur frequently causes the water table to rise nearly to the soil surface. The water displaces oxygen in the soil, thus causing soil conditions that adversely affect the development and growth of plant roots. The water table problem is more severe during the winter and early spring months (December through April) when evapotranspiration is low and precipitation is high. A high water table during this period may be particularly adverse to crops like sugarcane which is a stubble crop.

The purpose of this experiment was to determine the soil and crop response to subsurface drainage and to determine if crop production efficiency could be increased with subsurface drainage.

LITERATURE REVIEW

Experiments with subsurface drainage for sugarcane in Louisiana were conducted in the late 1800's. A Louisiana Experiment Station Bulletin in 1889 reported 25 and 30 percent increases in cane and sugar yields, respectively, with subsurface drainage (7). In a later bulletin, it was reported that, due to improper outlets, sediment had accumulated in the tiles causing them to gradually become ineffective (8).

In 1972, Camp and Carter (1) installed a subsurface drainage experiment near Houma, LA with five different drainage treatments, each with the drains emptying into sumps equipped with electric pumps for discharging drain outflow into surface drainage ditches. The success of these drainage systems prompted them to install several other drainage systems to determine soil and crop response to subsurface drainage on several different soil types. The results from these experiments have been reported (2, 4, 5).

Subsurface drainage experiments for sugarcane have also been reported from other countries. Pao and Hung (9) obtained a marked reduction in number and length of stalks, cane yield, sucrose content and root weight with the water table at 20 inches as compared with one at 60 inches. Gosnell(6) reported that a 10-inch water table inhibited sprouting of sugarcane at planting and ratooning and caused large reductions in plant population, stalk length, cane yield, and sugar yield. A 20-inch water table gave intermediate results. There was no difference in growth of cane between 30-, 40-, and 50-inch water tables, which gave the best results.

In small replicated plot experiments in Louisiana, Carter (3) found that a 12-inch water table during the dormant and early growth period (December - March) significantly decreased cane and sugar yields. This experiment demonstrated that the dormant and early growth periods were critical times when subsurface drainage was needed.

MATERIALS AND METHODS

A Jeanerette (Typic Argiaquoll) silty clay loam site on the M. A. Patout and Son's farm in Iberia Parish, Louisiana was selected for this experiment. The site consisted of four fields of slightly undulating land, each about four acres (200 x 800 feet) in size. Three fields were subsurface drained, each with different drain spacings, and one field, without subsurface drains, was used as a check. The three subsurface drained fields had four, three, and two drain lines spaced 45, 90, and 135 feet apart, respectively (Figure 1). Subsurface drainage was accomplished by installing 4-inch diameter drain tubes wrapped with Typar[1/] filter during the summer of 1978. A drain tube plow equipped with a laser grade control system was used for installation. The corrugated, perforated, polyethelyne drain tubes were installed an average of three feet below the soil surface on 0.15% slope. Sumps were installed to collect water from the drains because the drainage ditch was not deep enough to allow gravity drain outlets. Electric pumps discharged water from the sumps into the drainage ditch. Water level recorders were installed midway between two drains in each drainage treatment and in the center of the undrained area to monitor the water table. These recorders remained in place throughout the 3-year experiment except for short periods (about one month from mid-November to mid-December) in the fall of 1980, 1981, and 1982 when they were removed for harvest. A recording rain gauge was installed on site to collect precipitation data.

Sugarcane variety NCo 310 was planted in all fields in the fall of 1978. Due to a stand failure, the crop was replanted in the fall of 1979. Conventional practices including planting on 12-inch high rows spaced 70 inches apart were used. Herbicide was applied at planting and again each spring. In addition, the fields were cultivated to insure good weed control. Pesticides for controlling the sugarcane borer were applied as needed. Fertilizer was applied each spring using recommended rates.

The plant crop was harvested in the fall of 1980. First and second ratoons were harvested in 1981 and 1982, respectively. A mechanical harvester cut, topped, and placed the cane stalks in 3-row windrows after which the leaves were removed by burning.

[1/] Mention of trademark, proprietary products or vendor does not constitute a guarantee or warranty of the product by the U. S. Department of Agriculture and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

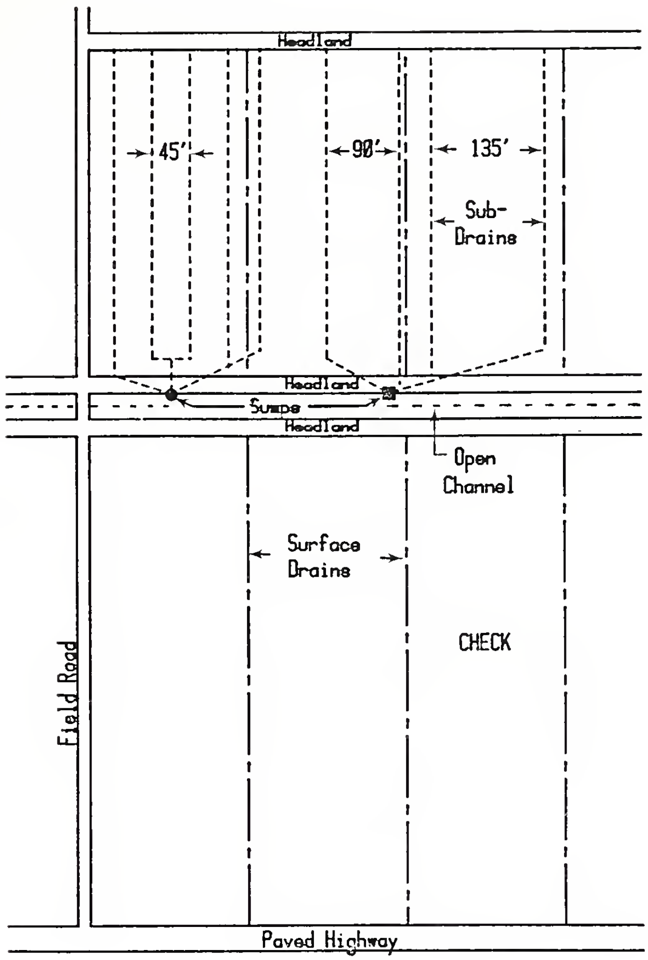

Figure 1. Field layout of subsurface drainage experiment in Iberia Parish, Louisiana.

Yields were estimated by taking a trailer load of cane from four measured areas (each approximately 0.25 acres in size) in each treatment. The cane was weighed and subsampled for juice quality determinations at the sugar mill.

Plant populations were estimated by counting the stalks in four different 100-foot sections of rows in each treatment. Mean stalk weight was calculated from cane weight and number of stalks per unit area.

RESULTS AND DISCUSSION

Annual rainfall for each of the three years was 66, 45, and 73 inches for 1980, 1981, and 1982, respectively (Table 1). Annual rainfall averages 60 inches; thus, rainfall was 10% above, 25% below, and 22% above average in 1980, 1981, and 1982, respectively.

The water table in all fields fluctuated throughout the experiment, but the water table in the nondrained field fluctuated much closer to the soil surface than those in the drained fields. Examples of water tables in drained and nondrained fields are shown in Figure 2.

Table 1. Monthly and annual rainfall at the Patout experimental site in Iberia Parish, Louisiana.

Month	year 1980	1981	1982
	inches		
January	6.24	1.37	2.54
February	.58	3.15	4.79
March	9.47	.85	1.60
April	10.14	3.40	6.61
May	11.06	1.28	4.73
June	1.09	8.70	4.43
July	4.30	6.98	8.40
August	3.45	6.18	8.45
September	7.12	3.15	8.80
October	4.78	2.13	4.36
November	6.08	3.05	2.44
December	1.67	4.62	14.95
Total	65.09	45.06	72.60

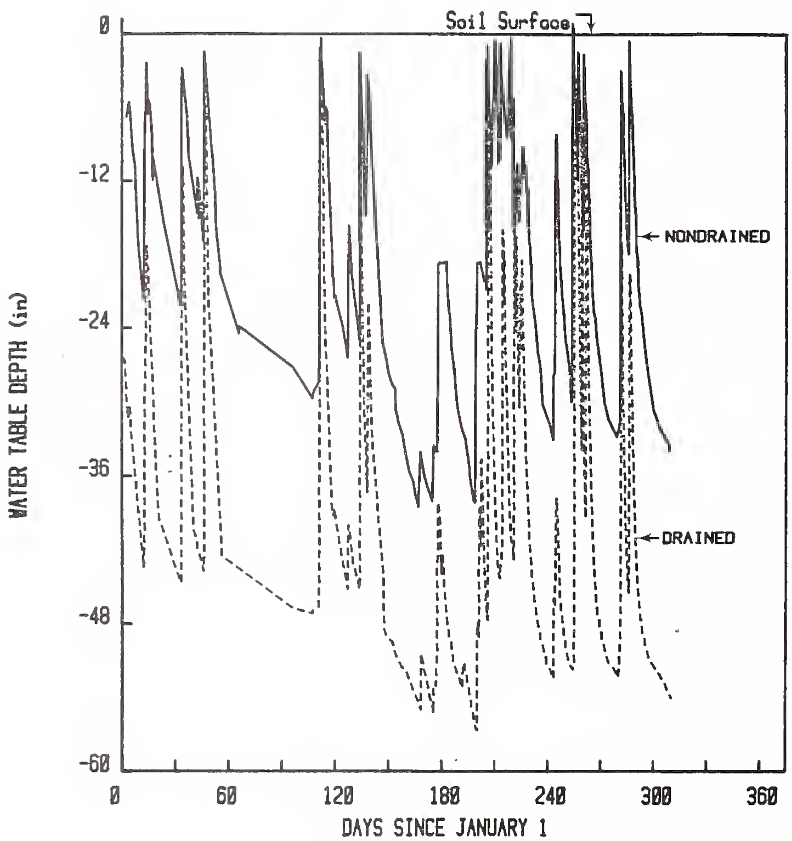

Figure 2. Water tables from nondrained and drained (90-foot spacing) fields in Iberia Parish, Louisiana, 1982.

The sum of excess water (SEW) was proposed by Sieben (10) as a way to determine excess soil water stress due to a high water table. He determined the amount of time and how far within a foot (base line) of the soil surface the water table was during the year and reported the data as depth-days. Any depth below the soil surface can be used as a base line. Since sugarcane in Louisiana is planted on high seedbeds, SEW determined from a base line of 18 inches may be near optimum for calculating SEW for use as an indicator of water table stress. In analyzing the data from this experiment, two different base lines (12 and 18 inches) were used. For a given base line, the higher the number (inch-days), the more severe the water table stress. SEW calculations were made both for the water tables in the 90-foot drain spacing treatment and for the nondrained treatment (Table 2). Water table data during the latter part of 1981 and 1982 were not included in the SEW calculations because the water table recorders were removed from about mid-November to mid-December each year for harvest. As shown in Table 2, water stress in the nondrained field was much more severe than it was in the drained field. The stress was also more severe in 1980 and 1982, the years with above average rainfall, than in 1981 when rainfall was below average.

Table 2. Water table stress as indicated by the SEW concept for sugarcane in Jeanerette silty clay loam soil in Iberia Parish, Louisiana.

Year	---------------- Water stress (inch-days)---------------			
	Nondrained		Drained[1/]	
	SEW_{12}	SEW_{18}	SEW_{12}	SEW_{18}
1980	332	728	110	296
1981	183	380	5	29
1982	337	871	33	92

[1/]90-foot drain spacing

Sieben (10) reported that cereal crop yields begin to decline as SEW_{12} increased from 40 to 80 inch-days. SEW_{12} values exceeded 80 inch-days in the non-drained fields each year and exceeded 80 inch-days in the drained field in 1980. Previous work (unpublished) in Louisiana indicated that the SEW_{12} threshold for sugarcane yield decline may be greater than the 40 to 80 inch-days suggested by Sieben for cereal crops.

Among the four fields, cane and sugar yields were highest for the subsurface drained fields with 45- and 90-foot drain spacing (Table 3). Yields were lowest on the nondrained field except in 1980 when cane yield for the nondrained field was higher than that for the 135-ft drain spacing field. The highest average sugarcane yield (35.2 T/A) was produced on the 45-foot drain spacing field, which was 7 T/A (26%) more than the yield for the nondrained field.

The similar cane and sugar yields measured from the 45- and 90-foot drain spacing treatments for this 3-year period indicated that the 90-foot spacing may be adequate for draining this soil. When similar crop response is measured from different drain spacing treatments, the wider drain spacing is preferred from an economic standpoint, since the unit cost for installing subsurface drains varies inversely with drain spacing.

The 3-year average sugar yield from fields with the more closely spaced drains (45- and 90-foot spacing) was 1500 lbs/A (33%) more than the yield from the nondrained field (Table 3). This higher sugar yield was due to higher cane yields and higher sugar per ton of cane from the drained field. Average sugar yield from the 135-foot drain spacing field was 5094 lbs/A or 843 lbs/A (20%) more than the nondrained field (Table 3).

There were small differences in plant population, but relatively large differences in stalk weight among the fields (Table 3). This indicates that subsurface drained fields had larger stalks, but no more stalks than undrained fields.

It is interesting to note that the highest yields measured during this experiment were in 1981, the year with below average rainfall. Annual rainfall in 1981 was 45 inches which is slightly above the 40 inches needed to satisfy annual evapotranspiration (ET). Even with this relatively low rainfall, the subsurface drained fields yielded higher than the surface drained fields. In an average year, rainfall is 60 inches, which exceeds ET requirements by 20 inches.

Sugar yield differences between drained and nondrained fields were more pronounced in ratoon crops than in the plant crop. Data in Table 3 show that yields between the 90-foot drain spacing and check treatments differed by 669 lbs/A, 1759 lbs/A, and 2197 lbs/A in plant, first ratoon, and second ratoon, respectively. Differences in yield between the 45-foot drain spacing and the nondrained fields were similar to those between 90-foot drain spacing and nondrained fields. These data indicate that subsurface drainage may be more effective in boosting sugar yields in ratoon crops than in the plant crop.

If differences observed are attributable to subsurface drainage, the value of the large increase in sugar yield would pay, within four years, for drain installation costs of about $325 to $350/A for 100-foot spacings at the current sugar price of $.20/lb. The drain outlet problem experienced in the late 1800's has been solved by using sumps, as shown by the success of this and other experiments conducted in Louisiana in recent years.

Table 3. Cane yield, sugar yield, plant population and stalk weight from a subsurface drainage experiment on Jeanerette silty clay loam soil in Iberia Parish, Louisiana.

Treatment	Year	Cane Yield (T/A)	Sugar Yields (lbs/T)	Sugar Yields (lbs/A)	Plant Population (Plants/A)	Stalk Weight (lbs/stalk)
45'	1980	35.8	146	5261	38,850	1.85
45'	1981	40.1	178	7114	37,331	2.15
45'	1982	29.6	165	4820	23,875	2.50
Average		35.2	163	5732	33,352	2.17
90'	1980	34.8	152	5281	37,147	1.90
90'	1981	41.3	172	7119	31,218	2.65
90'	1982	28.2	177	4979	28,958	1.94
Average		34.8	167	5793	32,441	2.16
135'	1980	29.2	173	5063	34,858	1.68
135'	1981	34.8	192	6701	33,568	2.08
135'	1982	24.6	144	3519	30,652	1.62
Average		29.5	170	5094	33,026	1.79
Check	1980	33.6	138	4612	33,517	2.00
Check	1981	30.8	174	5360	37,679	1.65
Check	1982	19.2	143	2782	25,991	1.47
Average		27.9	152	4251	32,396	1.71

Crop production efficiency can be enhanced considerably with subsurface drainage. Using data from this experiment, a sugarcane grower with 500 acres of land without subsurface drainage could produce about 1000 tons of sugar/year (average yield of 4251 lbs/A from Table 3). If the land were drained (90-foot drain spacing), the same quantity of sugar could be produced annually on only 366 acres, a reduction of more than 25 percent in land. Thus, considerable savings in operating costs for sugarcane production could be obtained by using subsurface drainage.

ACKNOWLEDGEMENT

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PRELIMINARY EVALUATION OF THREE METHODS FOR PREDICTING SUGARCANE STALK BRITTLENESS COMPARED TO DAMAGE FROM HURRICANE FORCE WINDS

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ABSTRACT

The selection and release of non-brittle (resistant to breakage) sugarcane varieties (Saccharum spp.) is essential in Louisiana since the crop is planted and harvested by mechanical means. Varieties tend to grow very rapidly during summer months causing extreme susceptibility to top breakage from high wind. Brittle varieties cause problems for growers during planting and can result in serious economic loss due to sugarcane being left in the field at harvest. To measure stalk breakage, commercial and candidate sugarcane varieties were evaluated by three methods: a stalk-breaking device (SBD) which measures the deflection of a stalk before breakage and two external wind sources, a trailer-mounted airboat and a helicopter, to simulate damage caused by excessive wind. The results of the three methods of testing brittleness were compared to actual stalk breakage caused by Hurricane Danny. Results obtained with the SBD during August, a peak growth month, indicated among the commercial varieties, the variety NCo 310 was the least brittle and CP 72-356 was the most brittle, while in October at the beginning of harvest the recently released varieties CP 76-331 and CP 74-383 were less brittle than NCo 310, but CP 72-356 was again the most brittle. To demonstrate the effectiveness of an external wind source, the use of a trailer-mounted airboat resulted in notable differences among varieties in top breakage as well as breakage at the base of the stalks during both August and October. With the use of a helicopter in August 1984 the variety CP 72-356 broke more than the other varieties tested, with 75% of its tops broken. All three methods confirmed that CP 72-356 was the most brittle commercial variety tested. The results agree with broken stalk counts made in commercial fields of the same varieties following Hurricane Danny, which occurred on August 15, 1985. The variety CP 72-356 had 73% of its tops broken and suffered considerably more damage than the other commercial varieties evaluated.

INTRODUCTION

It is essential that sugarcane varieties in Louisiana are non-brittle during the planting and harvesting period since practically all of the crop is planted and harvested by mechanical means. Brittleness affects efficiency of planting and results in serious ground loss (scrap) in the field at harvest. The sugarcane crop is sometimes subjected to high winds and breakage associated with thunderstorms and hurricanes during the growing and harvest season (2, 7). For these reasons, stalk brittleness is an important consideration in a variety development and selection program. Currently, varieties are observed for brittleness in the replicated yield trials during cutting by mechanical harvesters and the scrap loss at harvest is used as a measure of brittleness (5, 6). This information is presented in variety recommendations to advise growers on harvestability (1).

One of the first methods to evaluate brittleness was a hand-held stalk-breaking device (SBD) which measures deflection of a stalk before breakage (3, 4). The early work showed that differences in brittleness could be measured between varieties using the (SBD); however, the method has not been adopted due to lack of personnel. This paper further evaluates the use of the SBD and compares two external wind sources, a trailer mounted airboat and a helicopter, as potential methods for predicting brittleness of sugarcane varieties. The results of all methods are compared to actual stalk breakage which resulted from the 161 km/h winds that occurred during Hurricane Danny on August 15, 1985 (7).

MATERIALS AND METHODS

Stalk-breaking device (SBD): Variety trials for measuring yield are routinely planted at Houma, Louisiana. From these trials, nine varieties were selected in the plant-cane crop of erect sugarcane to measure brittleness using the SBD. The varieties had been planted on raised ridges 1.8 m apart and plots were 4.8 m long in a single row. Three plots of each variety were sampled to coincide with the planting period (on August 9) and with the harvest season (on October 12, 1984). On each sampling date, 10 stalks were broken in each plot using the SBD approximately

30 cm below the growing point. The greater the deflection needed to break the stalk, the less brittle is the variety. The unreleased varieties CP 78-303 and CP 78-304 were tested with commercial varieties CP 65-357, CP 70-321, CP 72-356, CP 72-370, CP 74-383, CP 76-331 and NCo 310.

Airboat: An airboat was mounted on a trailer approximately 1 m above the ground and parallel to the row. The propeller was powered by a 230 HP automobile engine. The wind generated by the propeller was estimated at between 121 and 129 km/h. Wind gusts were simulated by moving the boat rudder from side to side. Plots were 4.9 m long x 1.8 m wide. Three single-row plots were subjected to wind from the airboat for a period of one minute. The varieties CP 65-357, CP 70-321, CP 72-356, CP 72-370, CP 74-383, CP 76-331, CP 78-303, CP 78-304 and NCo 310 were evaluated by the method on August 9 and October 12, 1984. Percent stalk breakage was determined for each plot.

Helicopter: A small single-engine helicopter, normally used for applying pesticides in agricultural operations, hovered approximately one meter above the sugarcane canopy for one minute. The downdraft from the helicopter blades generated wind estimated from 129 to 145 km/h. The helicopter was centered over three rows of sugarcane which consisted of plots 4.9 m long x 1.8 m wide. Percent stalk breakage was determined on the commercial varieties CP 65-357, CP 70-321, CP 72-356, CP 72-370 and CP 74-383.

Hurricane Danny: Hurricane Danny entered the western part of the Louisiana sugarcane growing area, around Pecan Island on August 15, 1985. Wind gusts of over 161 km/h accompanied by 5-13 cm of rainfall were experienced in the area where the hurricane crossed the coast. The percent of broken tops was determined in commercial fields of the varieties CP 65-357, CP 70-321, CP 72-356, CP 72-370, CP 74-383, CP 76-331 and NCo 310. Counts were made at Peebles Plantation and Triple V Farms, which are located southeast of Lafayette, Louisiana. Counts were made in three plots, 4.9 m long x 1.8 m wide, in fields of each variety. Percent stalk breakage was determined for each plot.

The three methods of breakage and the effect of Hurricane Danny were compared by ranking the varieties to determine if the rankings were consistent by the chi-square method (8).

RESULTS AND DISCUSSION

Stalk-breaking device (SBD): The data from the SBD are shown in Table 1. The least brittle variety tested during August was NCo 310 with an average deflection of 4.3 cm. It was less brittle than the commercial standard, CP 65-357. The variety CP 72-356 appeared to be the most brittle of the nine varieties tested during August with an average deflection of 2.1 cm. All varieties except NCo 310 required greater deflection for breakage to occur on the October sampling date. This agrees with earlier sampling data that showed varieties become less brittle later in the season (3). The least brittle variety on the October date was CP 74-383; it was less brittle than either NCo 310 or CP 65-357. The variety CP 72-356 still required the least amount of deflection before breaking on the October sampling date.

Airboat: The results from the effect on sugarcane stalks of wind generated by the airboat are found in Table 2. Breakage from the airboat was separated into two classes, top and bottom, since varieties reacted differently to the force of the wind. A total of 85% of the stalks of the unreleased variety CP 78-304 broke at the base of the stalk from winds of 1-minute duration. More stalks were broken in the variety CP 78-304 than in CP 70-321 and NCo 310 on both sampling dates. The varieties CP 72-356 and CP 76-331 both had 52% of the tops broken from the winds of the airboat on the August sampling date, much less in October.

The combined breakage from base and top showed the varieties CP 72-356 and CP 78-304 experienced the most damage from winds generated by the airboat. The varieties CP 70-321, NCo 310 and CP 72-370 experienced the least amount of breakage. All varieties had more breakage in August than in October when they were more mature.

Table 1. Average deflection (cm) of 9 sugarcane varieties using stalk-breaking device (SBD) during 1984.

Variety	August	October
	(cm)	
NCo 310 1/	4.3 3/	3.1
CP 74-383 1/	3.5	4.4
CP 76-331 1/	3.4	4.0
CP 72-370 1/	3.1	3.9
CP 78-304 2/	3.0	3.2
CP 65-357 1/	2.7	2.8
CP 78-303 2/	2.3	3.0
CP 70-321 1/	2.2	2.8
CP 72-356 1/	2.1	2.5

1/ Commercial varieties.
2/ Candidate varieties.
3/ The greater the deflection the less the brittleness.

Table 2. Average breakage (%) of stalks of nine varieties at base, top, or combined base and top resulting from the use of airboat for 1-minute duration.

Variety	Base		Top		Combined base & top	
	August	October	August	October	August	October
	%					
CP 70-321 1/	13	1	11	6	24	7
NCo 310 1/	25	12	8	1	33	13
CP 72-370 1/	31	26	5	2	36	28
CP 78-303 2/	37	6	5	2	42	8
CP 74-383 1/	52	12	6	2	58	14
CP 65-357 1/	42	37	27	7	69	44
CP 76-331 1/	20	25	52	0	72	25
CP 78-304 2/	85	58	1	4	86	62
CP 72-356 1/	39	27	52	13	91	40

1/ Commercial varieties.
2/ Unreleased varieties.

Helicopter: The results of the top breakage from wind generated from the helicopter are found in Table 3. The variety CP 72-356, with 75% breakage, apparently was more brittle than all other varieties tested in August. This is in agreement with the results found for the other two methods; however, no other separation was found between varieties.

Table 3. Average breakage of sugarcane stalks during August by Hurricane Danny, airboat and helicopter compared to deflection values from the stalk-breaking device.

Variety	Hurricane Danny Broken	Hurricane Danny Rank	Airboat Broken	Airboat Rank	Helicopter Broken	Helicopter Rank	Deflection (cm)	Deflection Rank	Ave. Rank[1/]
	(%)		(%)		(%)				
CP 72-370	3	1	5	1	13	1.5	3.1	2	1.4
CP 74-383	7	2	6	2	20	3.0	3.5	1	2.0
CP 70-321	13	3	11	3	13	1.5	2.2	4	2.9
CP 65-357	18	4	27	4	18	4.0	2.7	3	3.8
CP 72-356	73	5	52	5	75	5.0	2.1	5	5.0

1/ Chi square (χ^2) = 11.6, DF = 4, Prob. < 0.05.

Hurricane Danny: The results obtained in August for the three methods of testing brittleness were compared to the observations on stalk breakage by Hurricane Danny (Table 3). In the comparison of five varieties, the varieties which had the least breakage from the hurricane were CP 72-370 and CP 74-383. The varieties which experienced a moderate amount of breakage were CP 70-321 and CP 65-357. The variety CP 72-356 was the most brittle variety and lost 73% of its tops to the hurricane force winds.

When comparing the ranking of varieties for August from the three methods and the hurricane (Table 3), it appears that the results from the airboat are in the closest agreement with breakage caused by actual hurricane-force winds. This is followed by the results obtained by the helicopter. When the ranking of varieties, considering the three methods and the hurricane winds as four replications, are calculated, the varieties differ significantly from each other, the variety CP 72-356 being the most brittle in all tests (χ^2 = 11.6*; n = 4). If the data for the variety CP 72-356 are removed, the differences among the remaining varieties are almost significant (χ^2 = 7.7; n = 3; P = 0.052). The calculations show that the three methods and the hurricane effects are in agreement and together discriminate among varieties, ranking CP 72-356 most brittle, CP 65-357 more brittle, and not discriminating among CP 72-370, CP 74-383 and CP 70-321, the less brittle varieties. Although these results are preliminary, it appears artificial wind sources offer a possibility for screening new varieties of sugarcane for brittleness.

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THE SUGARCANE APHID, <u>MELANAPHIS SACCHARI</u> (ZEHNTNER), IN FLORIDA

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ABSTRACT

Research was conducted during 1985 on the sugarcane aphid in Florida cane. Large infestation levels of the aphid developed in some sugarcane fields during June. Samples were taken for aphids along a 5-inch section/leaf on lower, middle, and upper leaves; each leaf section was taken from the area on the leaf where aphids were most numerous. A mean number of 148 aphids/sample was present during late June. Population levels of the sugarcane aphid peaked during mid-July at 291 aphids/sample. Levels of the aphid decreased thereafter, and only three aphids/sample were present in early September. Fungal pathogens, primarily <u>Verticillium lecanii</u>, were the most important natural enemies of the sugarcane aphid, but a parasite (<u>Lysiphlebus testaceipes</u>), a coccinellid beetle, and a syrphid fly were also active against the aphid. Biological control appeared to have little impact against sugarcane aphid population levels during early to mid-summer when aphid levels were largest. Changes in environmental conditions were probably responsible for both the outbreak and initial decline in aphid levels. Biological control had a larger impact against sugarcane aphids during late summer.

INTRODUCTION

The sugarcane aphid, <u>Melanaphis sacchari</u> (Zehntner) (Homoptera: Aphididae), was first reported in the United States during 1977 on sugarcane near Belle Glade, Florida (4). This aphid occurs in many countries including Angola, Asia, Brazil, China (Taiwan), Colombia, Ecuador, Egypt, Ethiopia, Haiti, Hawaii, India, Indonesia, Japan, Jamaica, the Middle East, Nigeria, Pakistan, Peru, Philippines, Sudan, Thailand, Trinidad, Tabago, Uganda, and Venezuela (4). The sugarcane aphid was already widespread in Florida cane within the first year it was discovered (4,5) and at least 16 grasses were identified as host plants (4). Although Mead (4) observed many sugarcane fields infested by the aphid, he did not observe any economic damage. According to Summers (5), 800 acres of cane were sprayed during 1978 to control sugarcane aphids because population levels were large and honeydew/sooty mold growth was extensive. Sugarcane aphids continue to be widespread in Florida cane, and large infestation levels occasionally occur. These large infestations along with the associated buildup of honeydew and sooty mold are of concern to some growers, primarily because lower leaves of heavily infested plants frequently die.

Research is lacking on the sugarcane aphid as a pest of sugarcane. According to a South African Sugar Association report (1), severe outbreaks of the sugarcane aphid promote a heavy sooty mold on leaves which may block stomata, thereby affecting cane growth. Although the sugarcane aphid has been implicatd as a vector of sugarcane mosaic disease (2,3), mosaic is relatively uncommon in Florida cane, even in fields where sugarcane aphids have been numerous. Therefore, whether or not the aphid causes economic damage to cane in Florida primarily depends on whether or not direct feeding, honeydew and sooty mold buildup on leaves, or death of lower leaves results in economic damage.

During 1985, research was conducted to obtain information on population dynamics and biological control of the sugarcane aphid in Florida sugarcane.

MATERIALS AND METHODS

Large population levels of the sugarcane aphid were first noticed during June in two sections of cane (almost entirely CL 59-1052) in an area about ten miles southeast of Clewiston, Florida. Weekly leaf-samples for sugarcane aphids were taken from June 27 through September 6 in three infested fields. Two locations were sampled in one field and one location was sampled in each of the other fields. At each of the four locations, 15 leaves were examined for aphids on each sample date: five leaves were the lowest live leaves from five stalks, five leaves were the middle leaves, and five were the leaves of the top visible dewlap. The aphids were counted along five inches of each leaf at the area on the leaf where aphids were most numerous. Separate counts were taken of apterous aphids, alate aphids, mummified (parasitized) aphids, aphids infected by fungi, and aphids killed by predators. Predaceous insects feeding on aphids were identified and counted. Two

each of the bottom, middle, and upper leaf samples were held in the laboratory for emergence of parasites of the sugarcane aphid. The data were studied to assess the population dynamics of the aphid during the summer and the impact of natural enemies against population levels of sugarcane aphids.

RESULTS AND DISCUSSION

Sugarcane aphid populations were at relatively large levels ($\bar{x}$ = 148 aphids/5" leaf-sample) when sampling was initiated on June 27 (Figure 1). The total number of aphids on many leaves was well above 1000. Honeydew and sooty mold were present in large quantities on lower leaves. The data showed that levels of the sugarcane aphid peaked during the latter half of July ($\bar{x}$ = 291 aphids/sample) and decreased thereafter. The last samples taken on September 6 showed that aphid levels had decreased to only three aphids/sample, and this was also usually the total number of aphids/leaf. Relatively few alate aphids were observed during the study. Alates tended to be more numerous during late June (mean of 2.2% alate aphids/sample) and July (mean ranged from 0.6 to 1.5% alate aphids/sample) than during August and early September (less than 0.5% alate aphids/sample).

Although sugarcane aphids were very abundant during late June and July, relatively few aphids were killed by natural enemies during this time period (Figure 1). A mean of only 5.1% of the aphids were observed dead due to natural enemies on June 27. The mean percentage of aphids killed by natural enemies increased from 5.8% in early July to 25% in late July. Biological control of the sugarcane aphid peaked during August at a mortality rate of about 48%. The percentage of aphids killed by enemies remained relatively large throughout August (25 to 45%). Overall, biological control appeared to have little impact against aphids during early to mid-summer but a large impact during late summer. Changes in environmental conditions were apparently responsible for both the large outbreak and initial reduction in aphid levels. During some years in some areas, biological control may play a larger role in the early control of aphid outbreaks.

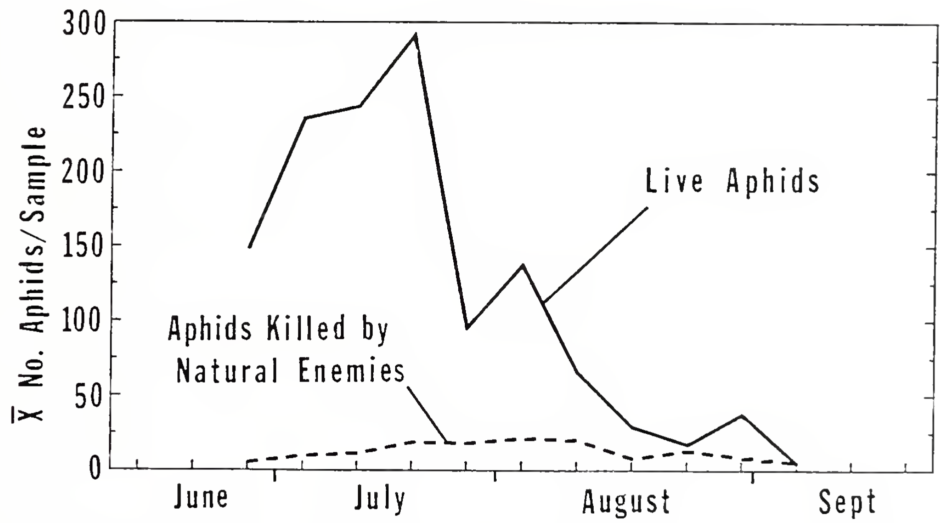

Figure 1. Population dynamics and biological control of sugarcane aphids during the summer.

Fungal pathogens (primarily *Verticillium lecanii* (Zimmerman) Viegas but occasionally an unidentified gray fungus) were the most important natural enemies of the sugarcane aphid at the locations studied (Figure 2). Control of aphids by fungi increased during the latter half of July and peaked during August at an apparent mortality rate of about 45%. All aphids on some leaves were killed by *Verticillium* during August. Predators (primarily the small coccinellid *Diomus terminatus* (Say) but also the syrphid fly *Allograpta exotica*) and the aphidiid parasite *Lysiphlebus*

testaceipes (Cresson) were less important natural enemies of the sugarcane aphid. The mean number of D. terminatus larvae/sample ranged from 0.3 to 0.8 during June and July when sugarcane aphids were most numerous and from 0.0 and 0.1 during August and early September. During July, as many as five D. terminatus larvae were present on some leaf samples. Syrphid fly larvae were encountered less frequently than D. terminatus larvae. Overall, less than 3% of the aphids observed on each sample date were apparently killed by predators or parasites. Aphids killed by predators were recognized as being deflated and bluish in color. Parasitized aphids were typical mummies.

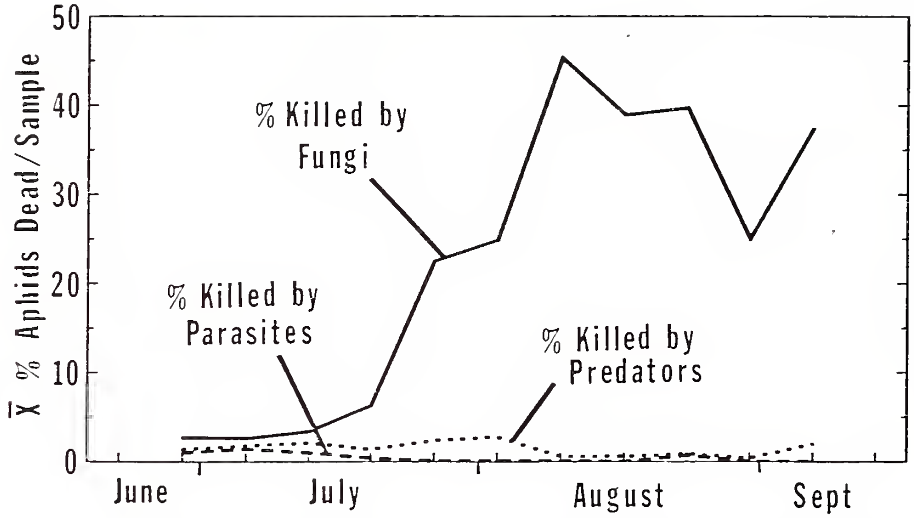

Figure 2. Percent mortality of sugarcane aphids caused by fungi, parasites, and predators.

During late June through early August when sugarcane aphids were most abundant, two to four times as many aphids were found on lower and middle leaves as on upper leaves. Aphids colonized the underside of leaves. Sugarcane aphids had no observable effect on whorl leaves; these leaves continued to develop and function in spite of the large numbers of aphids on lower and middle leaves. The lower leaves of heavily infested sugarcane plants frequently died. The mean number of dead leaves/stalk on July 19 ranged from 2.8 to 4.5 (30 to 50% dead leaves/stalk). In general, the number of dead leaves/stalk was related to the severity of the sugarcane aphid infestation at each location. The death of lower leaves was slow. Aphids left dying or dead leaves and migrated upward.

The data from this study showed that, if infestations of sugarcane aphids are shown to cause economic damage to sugarcane, biological control of the aphid may not occur fast enough to circumvent damage.

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EFFECT OF THE ENVIRONMENT ON SUGARCANE RUST EPIDEMICS IN FLORIDA

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ABSTRACT

The progress of sugarcane rust infection in the field was monitored at two locations during each of the crop years 1984 and 1985. The number of spores trapped in spore collectors deployed at periodic intervals was used as an indicator of the severity of infection. In 1984, measurable spore production began in January and continued through June; in 1985, spore production began in mid-March and continued through June. Spore levels subsided during the period July through September in both years. The production of spores peaked on May 4 and May 16 in 1984 and 1985, respectively. Ambient air temperature played an important role in the progress of the rust epidemics studied. The mild 1983-84 winter led to rust spore detection as early as January, while the severe 1984-85 winter delayed the onset of rust spore detection until mid-March. Temperatures above 30°C limited the progress of rust infection in the field. When daily temperatures exceeded 30°C on a regular basis, rust spore levels quickly subsided.

INTRODUCTION

Since it's discovery in Florida in 1979 (1), sugarcane rust, caused by <u>Puccinia melanocephala</u> H. Syd and P. Syd, has had a major impact on the Florida sugarcane industry. Susceptibility to the disease has eliminated or contributed to the decline in acreage of several commercial varieties and to the elimination of many promising varieties from the breeding programs of the United States Sugar Corporation and the United States Department of Agriculture. Although the disease has been present in the cane-growing area in Florida each year since the initial discovery, the intensity, duration, and time of occurrence of the peak periods of rust infection have varied from year to year.

Sugarcane rust is generally considered to be a cool-to-warm weather disease (2,6). Several researchers have reported that very hot weather causes a reduction in the amount of rust infection in the field (2,3,5). Thus it follows that changes in temperature during the year and variation in temperature between years might account for the year to year differences with respect to the peak periods of rust infection and their differences in intensity. This report attempts to correlate the progress of rust epidemics in the field to ambient air temperatures experienced during 1984 and 1985.

MATERIALS AND METHODS

The progress of rust epidemics occurring in 1984 and 1985 was followed using the number of airborne urediospores trapped by spore samplers as a measure of the intensity of the rust epidemics in progress. Two rotorod spore samplers (Ted Brown Associates, Los Altos Hills, CA) were deployed at periodic intervals at two locations each year. In 1984, one sampler was placed in a 4.3 acre planting of the very susceptible variety CL 73-451 (Location 1). The second spore sampler was located in the midst of a field containing 0.02 acre research plots of resistant to moderately susceptible varieties (Location 2). In 1985, both samplers were placed in a field containing 0.02 acre research plots of varieties that, except for indicator varieties, had not been rated for rust resistance. One sampler was located in a plot of the very susceptible variety CL 41-223 (Location 3), while the other was located in a plot of the moderately susceptible variety CP 63-588 (Location 4). All sample locations were in Palm Beach County, Florida.

The spore samplers were set out at 4-9 day intervals which began in January in 1984 and in February in 1985 and continued through July of both years. After July, the interval between sample dates varied from 6-21 days. The spore samplers were timed to operate for 6 min/hr for a 24 hr period. Throughout the year, the spore samplers were adjusted so that the samplers were maintained at a level approximately 15 cm above the top of the overall leaf canopy. The number of spores per cubic meter of air sampled was estimated by direct counting of impacted spores under a microscope at 100X.

Temperature data were collected at weather stations located within 1/2 mile of locations 1 and 2 and in the same field as locations 3 and 4. Maximum and minimum temperatures were recorded for all days during the sampling period of both years. Mean maximum and minimum temperatures associated with a given spore sample date were calculated by averaging the daily maximum and minimum temperatures for all days after the previous spore sampling date through the date of the sample.

RESULTS AND DISCUSSION

Puccinia melanocephala spores were detected in 1984 in the first sample on January 4 (Figure 1); in 1985, spores were first detected on March 15 (Figure 2). Larger numbers of spores were trapped at locations 1 and 3, which contained very susceptible varieties, than from locations 2 and 4, which contained resistant to moderately susceptible and moderately susceptible varieties, respectively. When the relative spore load associated with each variety-site combination is taken into account, it is seen that rust spores were abundant February to June in 1984 and April to June in 1985. The number of spores detected at all locations from July to September (October in 1985) was low. In 1984, peak numbers of spores were trapped on May 4 at locations 1 and 2, while in 1985 the peak numbers were trapped on May 16 at location 3 which contained the susceptible variety CL 41-223 (1985), and on May 31 at location 4 which contained the moderately susceptible variety CP 63-588.

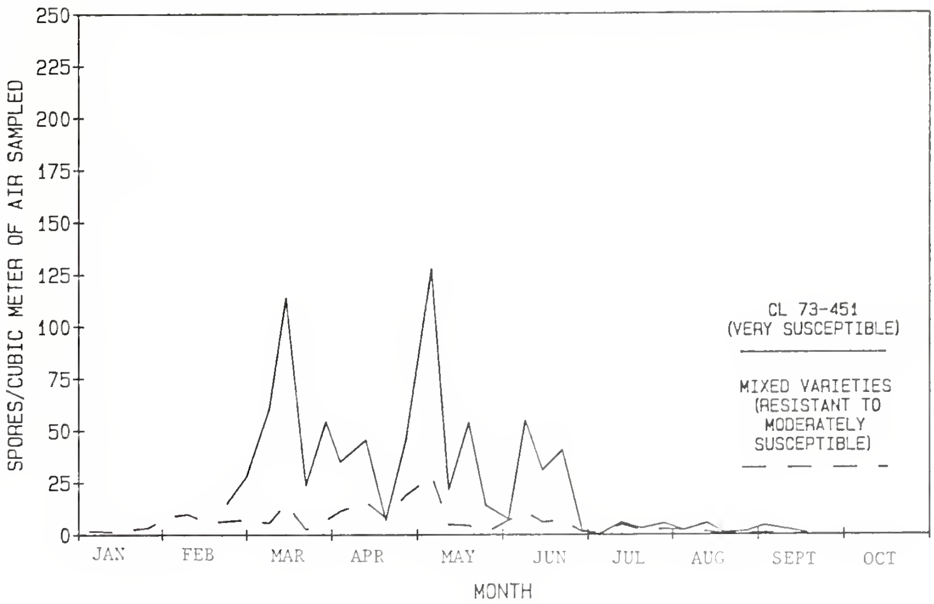

Figure 1. Number of urediospores trapped by spore collectors at two locations during 1984.

When the temperature data were compared with the spore-trapping data, it became apparent that prevailing weather conditions greatly influenced both the onset and the progress of the sugarcane rust epidemics. In 1984, rust spores were detected approximately 2.5 months earlier than in 1985 (Figures 1 and 2). The 1983-84 Florida winter was relatively mild; the only killing freezes occurred on December 25-26, 1983. Despite the freezes, some fields containing susceptible varieties with lingering rust infections escaped with little freeze-associated damage. Thus, inoculum as well as susceptible host tissue was present early in the growing season at locations 1 and 2. On the other hand, the 1984-85 winter was severe; heavy frosts or killing freezes occurred on January 7, 21, 22, 23, and February 13-14, 1985. The freezes on January 21-23 were particularly heavy and killed virtually all exposed cane foliage in the Florida cane-growing area. Due to the lack of susceptible host tissue and the apparent reduction in the amount of initial inoculum available to

initiate widespread rust infection (9), the rust epidemic in 1985 began several months later than the one in 1984. Once the rust epidemics began in 1984 and 1985, generally increasing numbers of spores were detected until May, then spore levels began to decline and were at very low levels by July. After July the levels remained low.

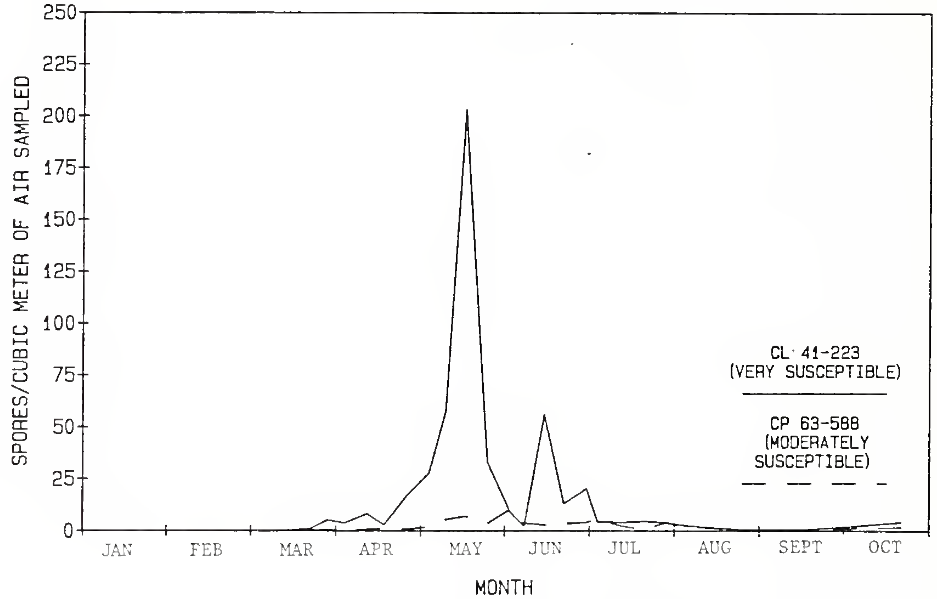

Figure 2. Number of urediospores trapped by spore collectors located in plots of two varieties during 1985.

High temperatures have been reported to be limiting to sugarcane rust infection based on field observations and laboratory measurements (2,3,5). Liu (3), and Liu and Bernard (5) reported that temperatures of 35°C and above limited rust infection in the field and prevented urediospore germination in the laboratory. Sotomayor et al. (8) also reported that 35°C. temperatures were detrimental to spore germination. Below 35°C, P. melanocephala spores have been reported to germinate over a range of temperatures from 5-34°C (5,6,8), with the optimum being 15-30°C (2,6,8). During the sampling periods in 1984 and 1985, daily maximum air temperatures rarely approached 35°C (Figure 3). Thus, the effect of high temperatures on spore germination apparently was not the limiting factor that slowed the progress of rust infection both years.

Sotomayor (7), and Sotomayor et al. (8) reported that the formation of appressoria was more sensitive to high temperature than was spore germination. Although appressoria were formed at 30°C, the number formed was lower than the number formed at temperatures below 30°C. Above 30°C, the number of appressoria formed was drastically reduced. Since appressoria are essential for infection (8), any factor, (e.g., temperatures above 30°C) which interferes with their formation would also inhibit the progress of rust infection in the field. Maximum daily temperatures above 30°C were common during both years (Figure 3) and were probably the single most important limiting factor to rust infection in the field.

If air temperatures above 30°C can serve as an indicator for the occurrence of conditions limiting infection, and if a period of approximately 8-11 days (4,7) is assumed to be the necessary period of time between spore germination and the production of a new generation of spores, then a decline in the number of spores trapped should be seen approximately 8-11 days after temperatures begin to exceed 30°C on a regular basis. After these two assumptions were incorporated into the data evaluation, it became apparent that temperatures above 30°C were closely

associated with a decline in the number of spores trapped in 1984 and 1985 (Figure 4). Temperature became a limiting factor in 1984 on April 25 and in 1985 on May 9 (Figure 4). The resulting decline in the number of trapped spores was seen after May 4, 1984, and May 16, 1985, or 9 and 7 days after temperatures became limiting in 1984 and 1985, respectively.

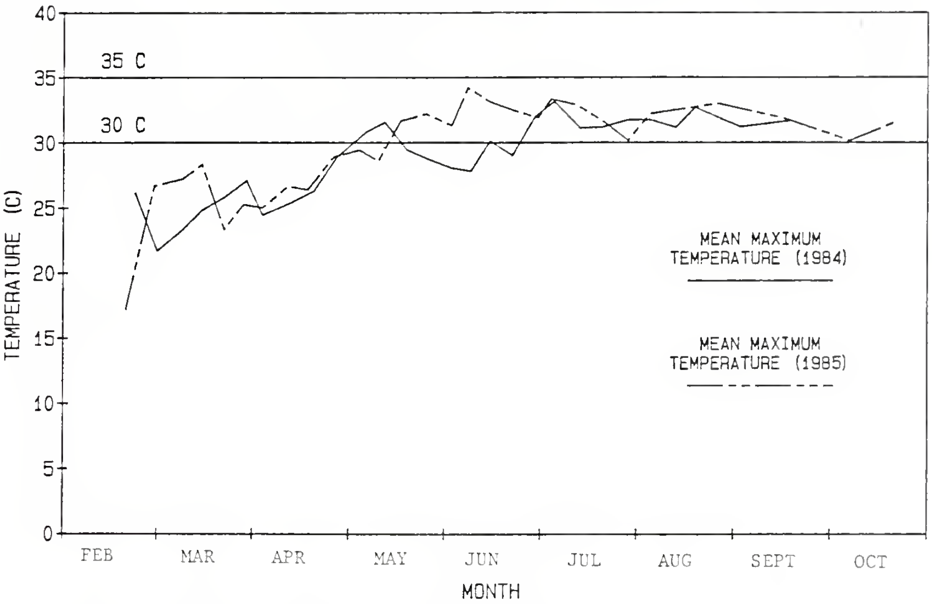

Figure 3. Mean daily maximum temperatures experienced during 1984 and 1985.

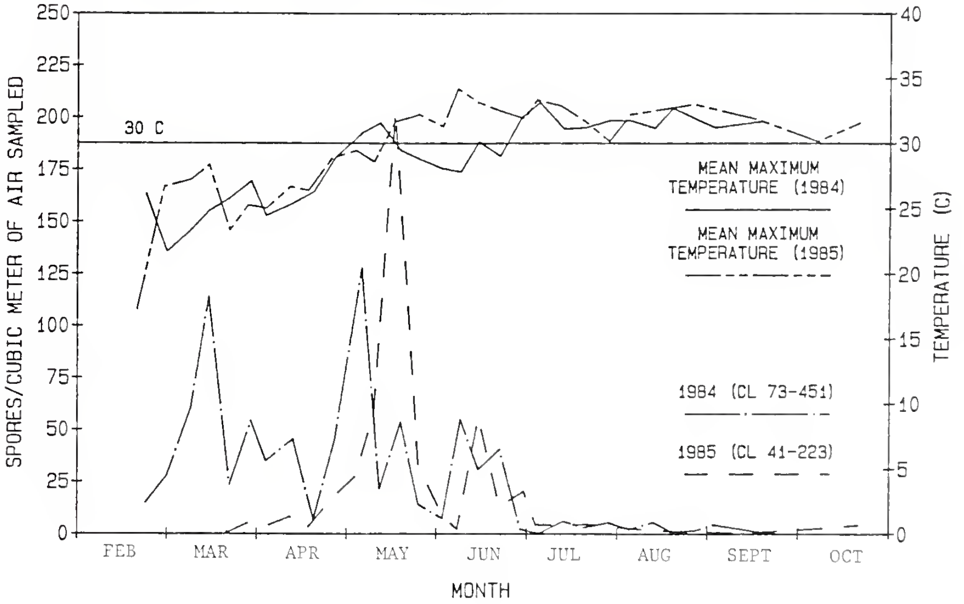

Figure 4. Number of urediospores trapped and mean maximum temperatures at two locations during 1984 and 1985.

After the initial sharp decline in spore production due to high temperature, the number of rust spores detected increased slightly during the month of June in both years. In 1984, temperatures during late May and early June were generally not high enough to be limiting to infection. In 1985, although mean maximum temperatures were above 30°C after mid-May and remained so through September, close examination of daily temperature data revealed that despite mean maximum temperatures above 30°C, there were days between sample dates with maximum temperatures below 30°C which would have been favorable for infection (Figure 5). Prior to April 25, 1984, and May 9, 1985, 95.2% and 92.9%, respectively, of the days between sample dates were favorable for infection, i.e., maximum daily temperature was less than 30°C. From April 25 to June 26 in 1984, and from May 9 to May 31 in 1985, only 53.2% and 27.3%, respectively, of the days were favorable for infection. Allowing for a suitable incubation period, these days favorable for infection could explain the spores detected in June. Beginning in July, only 14.4% and 11.0% of the days were favorable for infection in 1984 and 1985, respectively, and apparently account for the reduced level of spores trapped July-September.

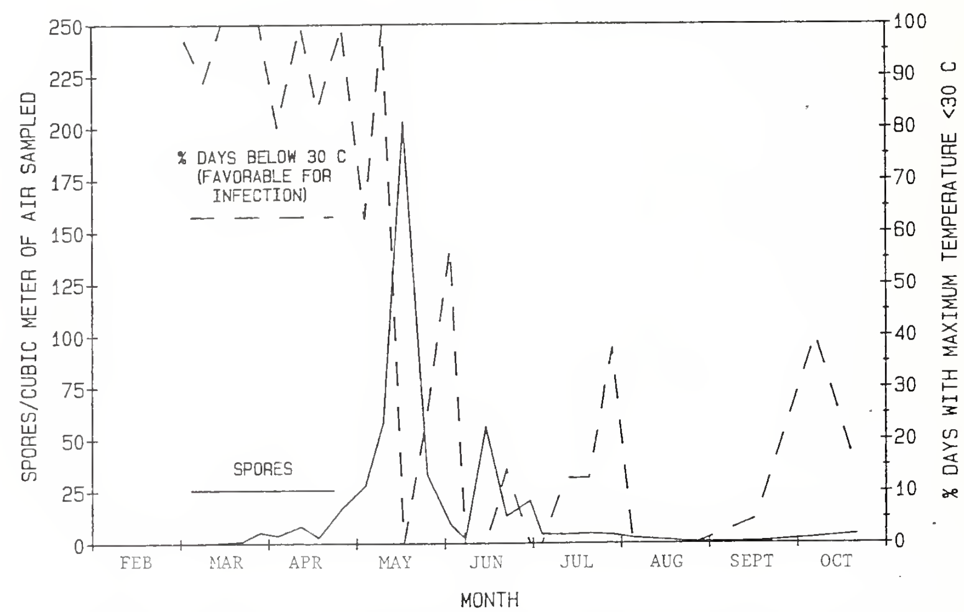

Figure 5. Relationship between the percentage of days between sample dates favorable for infection (mean maximum temperature <30°C) and the number of urediospores trapped during 1985.

In addition to accounting for the mid-season subsidence in rust infection during the year, infection-limiting temperatures appear to be responsible for some of the differences observed between years. In 1984, limiting high temperatures were experienced approximately 14 days earlier than in 1985 (Figure 4). The detection of peak spore numbers and the accompanying sharp decline in the number of spores detected occurred 15 days earlier in 1984 than in 1985. The effect of cold weather on the onset of the rust epidemics was discussed earlier.

The data presented here confirm observations made in the field over the period of time since rust was found in Florida. Mild winters with no late freezes have been associated with the early onset of rust infection, while rust infection has been observed to decline during the hot summer months. The data presented not only confirm the field observations; they also elucidate some of the specific conditions that affect the progress of rust infection in the field. In addition to providing a better overall understanding of the disease-host-environment interaction, these data should provide basic information useful in making predictions or comparisons of rust severity between years, locations, etc., and may be useful in determining the timing of fungicide applications should suitable chemicals become available or necessary. Although temperature appears to be the single most important factor in the onset, progress, and subsidence of rust epidemics, other factors such as humidity, mature plant resistance (5), and cultural practices undoubtedly contribute to the progress of rust epidemics in the field.

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A REVIEW OF IMPORTANT ASPECTS OF GENOTYPE-ENVIRONMENTAL INTERACTIONS AND PRACTICAL SUGGESTIONS FOR SUGARCANE BREEDERS[1/]

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Agricultural geneticists and breeders continually encounter differential effects of environments on quantitative traits of different genotypes. With a wide range of genotypic and environmental differences, the genotype x environment interaction often becomes large and more apparent compared with the main effects. Generally, successful researchers have felt the need for evaluating different genotypes (cultivars, varieties, strains, clones, breeds, etc.), especially if experimental, in several different environments. Whether or not the researcher is conscious of it, this need has been dictated by the underlying genotype x environment interaction. This interaction reduces the correlation between phenotypic and genotypic value. A relatively large genotype x environment interaction may cause relative rankings of genotypes to differ across environments. This interaction may preclude the use of genotype means across environments for advancing experimental genotypes from one stage to the next. Skinner et al. (16) provide some useful general discussion on genotype x environment interaction. However, many researchers have overlooked a linear statistical model which includes all main effects and interactions. The relative importance of interactions in relation to main effects can be determined by using this model. If genotypes are evaluated at multiple locations in different years, a measured trait value in a replication will be represented by:

$$X_{ijkm} = \mu + G_i + L_j + Y_k + R_m + GL_{ij} + GY_{ik} + LY_{jk} + GLY_{ijk} + E_{ijkm}$$

where:

X_{ijkm} = trait value

μ = overall mean

G_i = genotypic effect

L_j = location effect

Y_k = year effect

R_m = replication effect

GL_{ij} = genotype x location interaction effect

GY_{ik} = genotype x year interaction effect

LY_{jk} = location x year interaction effect

GLY_{ijk} = genotype x location x year interaction effect, and

E_{ijkm} = random error.

Nonsignificant GL, GY, and GLY interactions would indicate that little or no attention need to be given to locations or years in estimating the G effect. Theoretically, if the interactions were nonsignificant, the relative performance of each genotype could be established by obtaining data in only one environment. But all geneticists/breeders are aware that this ideal situation does not exist in practical performance trials. When an interaction is significant, its cause, nature, and implication should be carefully considered in breeding programs. It may be prudent also to consider stability of performance of genotypes across environments in conjunction with overall means. A genotype would be considered stable if the interaction component attributable to it is significantly less than or equal to within-environmental variance (experimental error), and a genotype would be considered unstable if its interaction component is significantly greater than the experimental error. For details on how to perform stability analysis, the reader is encouraged to refer to Kang and Miller (6), Lin et al. (10), and Shukla (15).

1/ Approved for publication by the Director of the Louisiana Agricultural Experiment Station as manuscript number 86-09-0028.

Several methods have been developed for determining stability of performance of genotypes tested across environments (6,10). Sugarcane (Saccharum spp.) researchers have employed several methods of evaluating varietal stability, (2,4, 6,11,12,13,14,17,19). The studies by Kang and Miller (6) and Milligan and Martin (12) have demonstrated the use of the stability-variance parameter ($\hat{\sigma}_i^2$) developed by Shukla (15) in sugarcane. This method is considered superior to those that employ regression of cultivar means on the environmental index (mean of all cultivars in a test at a location). Successful implementation of the stability-variance parameter in sugarcane experimental trials has been done by Glaz et al. (3). The calculation of this parameter has been facilitated by the development of an efficient computer program by Kang (5). It has now been established that Wricke's (18) ecovalence (W_i) and Shukla's (15) $\hat{\sigma}_i^2$ are essentially the same method (7). Heretofore, these two parameters had been treated as separate methods. However, because Shukla (15) has presented formulae for removing heterogeneity from the genotype x environment interaction variance, and partitioning the remainder of the genotype x environment interaction variance and assigning it to each genotype ($\hat{s}_i^2$ parameter estimate), it was suggested that $\hat{\sigma}_i^2$ and $\hat{s}_i^2$ statistics be used for stability analyses in preference to ecovalence (7).

Following calculation of stability-variance parameter estimates, the breeder/geneticist should endeavor to identify genotypes with relatively high mean yields and relatively low stability variances if broader adaptability is the goal. Location-specific genotypes can also be identified by use of the stability-variance parameter. It is realized, however, that a researcher may often forgo time-consuming stability analysis. Ignoring this important parameter defeats, in a large measure, an important purpose of testing genotypes across environments. Some may argue that breeders have made progress for many years without considering or using any stability parameters. However, we feel that with the use of a stability parameter, the selection process would become more precise and refined, and be expected to result in greater success.

Usually, in the early stages of breeding programs, a large number of experiemental genotypes are generated for evaluation. To make a breeding program efficient, the expenditure of resources such as time, labor, space, and associated expenses on unacceptable genotypes must be minimized. To achieve this goal, unadapted or unacceptable genotypes must be eliminated as quickly as possible. An optimal balance between number of environments (years and locations) and plot size should be determined. A breeding program should be designed to identify genotypes with superior, stable performance across environments at an early stage. This objective may be achieved by decreasing plot size but adding more test environments in the earliest possible clonal selection stage. Research would be needed to determine the minimum plot size which would be large enough to provide an accurate estimate of yield potential. Skinner et al. (16) recognize that genotype x environment interactions influence the optimum number of locations for the early selection stages, but present no solution to the problem.

Allard and Hansche (1) have pointed out that genotype x year interactions in field performance trials are different from genotype x location or genotype x treatment interactions because of the unpredictability of years. They cautioned breeders not to develop varieties suited to special circumstances (such as years) that the breeders cannot foresee. This suggestion would be applicable to most crops. However, it would not be fully applicable to a vegetatively propagated crop such as sugarcane and to other crops where ratoon crops can be harvested. The effect of ratooning is relatively predictable for most traits in sugarcane. For example, a ratoon crop generally has smaller stalk diameter, and lesser stalk weight, but has higher Brix, sucrose concentration (or sugar per ton of cane), and purity than the plant-cane crop (8). It should be noted, however, that the genotype x crop interaction effect in sugarcane is usually confounded with genotype x year interaction (8,16). The implications of such confounding are addressed by Kang et al. (9).

Once stability analysis is accepted and incorporated into sugarcane breeding programs, elucidation of the causes of genotype x environment interactions and their relative importance should be undertaken. Determination of repeatability of the stability-variance parameter between selection stages (clonal repeatability) is also a worthwhile objective. If this parameter were repeatable between selection stages it could be a useful selection criterion. The stability-variance parameter should be estimated for clones in those selection stages in which genotypes are grown in multiple environments.

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SEASONAL FLIGHT ACTIVITY OF ADULT SUGARCANE GRUBS IN FLORIDA

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ABSTRACT

Research was conducted on the seasonal flight activity of four grub species in sugarcane fields in southern Florida. Ligyrus subtropicus, Cyclocephala parallela, and Phyllophaga latifrons had unimodal flight patterns. Adults of these species usually flew between late April and late June. C. parallela and P. latifrons began flying several weeks before L. subtropicus. P. latifrons tended to fly over a longer period of time than L. subtropicus or C. parallela. Anomala marginata had a bimodal flight pattern, with one flight occurring in early spring and one in late summer.

INTRODUCTION

Sugarcane fields in southern Florida are frequently infested by one or more of the following species of grubs (Coleoptera: Scarabaeidae): Ligyrus subtropicus (Blatchley), Cyclocephala parallela Casey, Phyllophaga latifrons (LeConte), Anomala marginata (Fab.), and Euphoria sepulchralis (Fab.) (3). The specific complex of grub species in a cane field is generally related to soil type; for example, L. subtropicus occurs primarily in highly organic soils (muck) while C. parallela and P. latifrons occur in sand-muck mixtures (3). L. subtropicus is the most destructive sugarcane grub and sometimes causes substantial yield reductions (5). Sugarcane fields infested by L. subtropicus are usually easy to detect due to the extensive damage this large grub causes. C. parallela is also thought to be an important pest (3,6), but damage by C. parallela, P. latifrons, A. marginata, and E. sepulchralis to sugarcane has not been evaluated.

A knowledge of the seasonal phenology of sugarcane grubs is useful for understanding their damage (2) and for the development of grub management strategies. Information on seasonal flight activity is useful for determining when during the season new grub infestations develop, which in turn has implications on the timing of scouting and control strategies to prevent damage. Adults of each grub species noted earlier except E. sepulchralis are attracted to blacklight traps and, consequently, their flight patterns are relatively easy to monitor. Seasonal flight activity of L. subtropicus has been documented (5,6) and the flight activity of C. parallela has also been studied (6). During 1983-1985, research was conducted on the flight activity of L. subtropicus, C. parallela, P. latifrons, and A. marginata. Although seasonal flight activity of L. subtropicus and C. parallela had been studied, data were also collected for these species to facilitate better seasonal flight comparisons among the four species.

MATERIALS AND METHODS

Adult grubs were trapped with an Ellisco, Inc., general purpose blacklight trap with a 15-watt tube positioned 1.5 m above the ground. The trap was run one night each week from May 10 - November 1, 1983, from March 6 - November 30, 1984, and from February 18 - November 30, 1985. Trapping was conducted at the U.S. Sugar Ritta Plantation located about 8 km southeast of Clewiston, Florida. The soil in the area was highly organic (47 to 74% organic matter, $\bar{x}$ = 68%) with an average mineral content of 26% and an average silica content of 6%. The trap was operated at a different site at Ritta Plantation each year, with approximately 1-2 km between trapping sites. Trapping sites were adjacent to stubble sugarcane. At each site, the trap was run directly in a sugarcane field until the height of sugarcane reached about 1 m, after which time the trap was run at the outside edge of the field. The numbers of adult grubs collected each night were recorded, and seasonal flight activity for each grub species was determined.

RESULTS AND DISCUSSION

Adults of L. subtropicus were collected at blacklight traps from early May to early August (Figure 1). Their peak flight period usually lasted for 3-4 weeks during June. These data were similar to those presented by Sosa (5) and Watve and Shuler (6). A total of 20, 98, and 67 L. subtropicus adults were collected during 1983, 1984, and 1985, respectively.

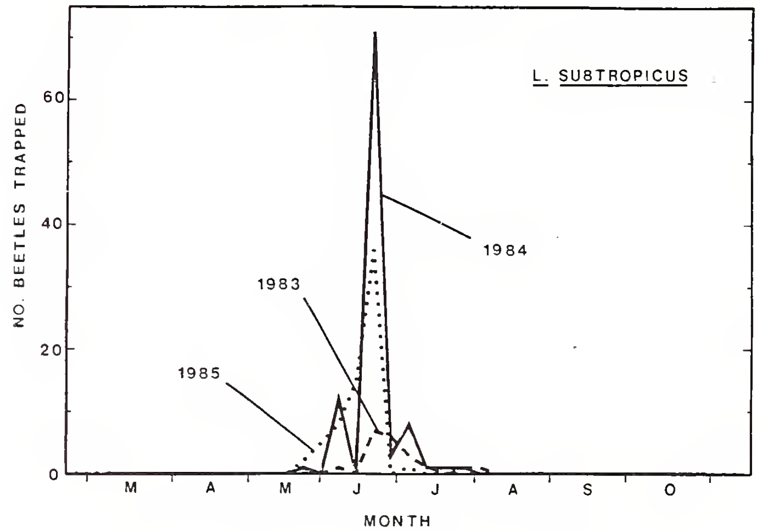

Figure 1. Seasonal flight activity of Ligyrus subtropicus in Florida sugarcane fields.

C. parallela adults were collected from early April to mid-June, with peak flight activity lasting for 3-5 weeks between mid-April and late May (Figure 2). These data were in agreement with those presented by Watve and Shuler (6). Although C. parallela was already flying when trapping was initiated in 1983, a total of 438 adults was still collected. A total of 877 adults of this species was collected during 1984, but only 178 were collected during 1985.

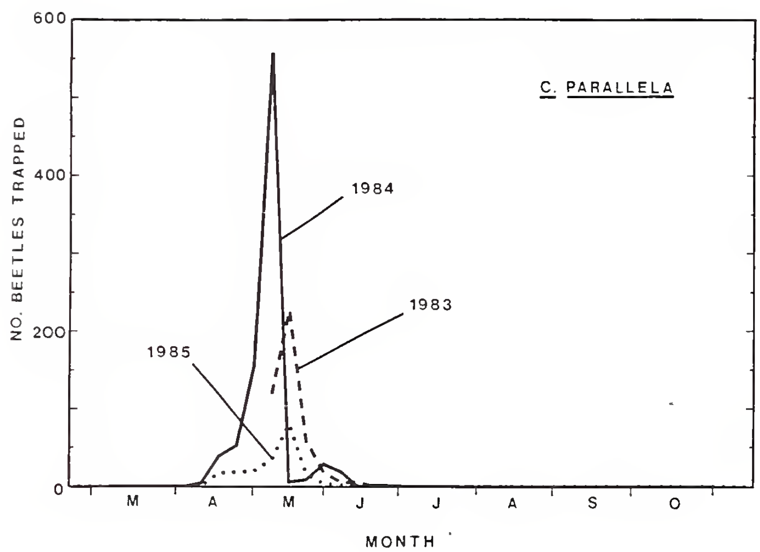

Figure 2. Seasonal flight activity of Cyclocephala parallela in Florida sugarcane fields.

Adults of P. latifrons were collected at blacklight traps from late March to mid-July (Figure 3). Peak flight activity of this species usually lasted for 6-7 weeks between mid-April and late June. A total of 148 P. latifrons was collected during 1983, 242 were collected during 1984, and only 68 were collected during 1985.

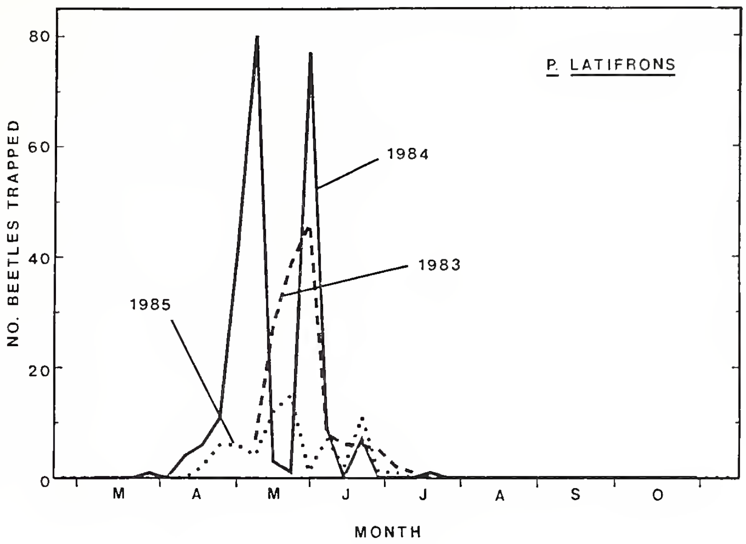

Figure 3. Seasonal flight activity of Phyllophaga latifrons in Florida sugarcane fields.

A. marginata had a bimodal flight pattern. This species was collected at traps from mid-February to early June and again from mid-July to early November (Figure 4). Peak flights of A. marginata occurred from late March to mid-May and again from early August to mid-October. The early spring flight usually lasted for 5-7 weeks while the late summer flight tended to last longer. Trapping was initiated too late in 1983 to obtain much data on the spring flight of A. marginata. A total of 133 adults was collected during the spring flight in 1984 but only 20 were collected during the 1985 spring flight. During the 1983 and 1984 fall flights, 20 and 51 adults were collected, respectively. A total of 450 A. marginata was collected at traps during the 1985 fall flight.

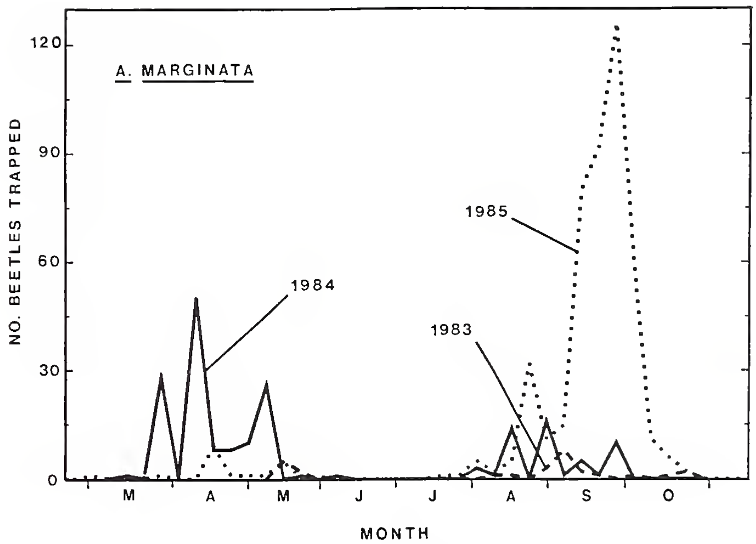

Figure 4. Seasonal flight activity of Anomala marginata in Florida sugarcane fields.

There was considerable variation among years in the number of adult sugarcane grubs collected at light traps. Differences in the number of beetles captured each year may have been related to the proximity of traps to grub-infested cane as well as to yearly fluctuations in population levels of each species. Also, differences in the height of cane during flights of L. subtropicus, C. parallela, and P. latifrons may have affected the number of these beetles collected at traps. It was of interest that more A. marginata were collected during the spring flight than the fall flight of 1984; the reverse was true during 1985.

This study showed that adults of C. parallela and P. latifrons fly earlier than L. subtropicus. Therefore, new infestations of C. parallela and P. latifrons should develop in sugarcane earlier than infestations of L. subtropicus; Cherry (2) found this to be true with respect to infestations of C. parallela and L. subtropicus. L. subtropicus and C. parallela had shorter periods of flight activity than P. latifrons. Ovipositional activity by this latter species may extend over a longer period of time.

The reason A. marginata displayed a bimodal flight pattern was not known. The seasonal phenology and life cycle of A. marginata in Florida sugarcane has not been researched, but adults had been observed during April (7). A. marginata apparently has a unimodal flight pattern in Kentucky during July (4) and in North Carolina during May-July (1).

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GROWTH CHARACTERISTICS AND CONTROL OF ASTER LATERIFLORUS AND WINTER WEEDS IN SUGARCANE

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ABSTRACT

Aster lateriflorus (L.) Britton (calico aster), a fall-flowering perennial that produces large numbers of wind-dispersed seed, rapidly invaded sugarcane fields in southern Louisiana during the 1970's. It has not been reported as a weed of other crops, and its spread into sugarcane can be attributed to two factors: 1) the large number of drainage ditches, occupying about 10% of the area of fields, that provide habitat and a base for the dissemination of seed; and 2) its tolerance to 2,4-D and partial tolerance to other widely used herbicides, including MSMA, terbacil, fenac and metribuzin. Seed germination and initial ratoon growth occur in winter, but maximum growth, reaching about 1.5 m in height, occur under the warm temperatures of spring and summer. Calico aster tolerates the late-season shading by sugarcane and seems well adapted for survival in sugarcane fields. The most effective herbicides for postemergence control of this weed were picloram, triclopyr, dicamba, and mixtures of dicamba with either asulam, silvex or atrazine. The kill of plants by these treatments was variable, ranging from only fair to excellent, but all were consistent in severely stunting growth. Atrazine at about 1.8 kg/ha provided only partial control of perennial aster plants but was effective for preemergence control of aster seedlings and for preemergence or postemergence control of the complex of winter weeds, including Carolina canarygrass (*Phalaris caroliniana* Walt.), timothy canarygrass (*Phalaris angusta* Nes ex Trin.), henbit (*Lamium amplexicaule* L.), common chickweed [*Stellaria media* (L.) Vill.], Carolina geranium (*Geranium carolinianum* L.), eveningprimrose (*Oenothera* sp.), and others. When uncontrolled in ratoon sugarcane fields, such a complex of weeds reduced the number of millable stalks at harvest by about 7%.

INTRODUCTION

The Weed Science Society of America has adopted the common name of calico aster for *Aster lateriflorus* (L.) Britton based on "Recommended Plant Names" by Beetle (1), and this name is used in this report.

Infestations of calico aster in Louisiana sugarcane fields were first observed in 1973 along lower Bayou Lafourche. These infestations were not being controlled even though the standard 2,4-D treatment had been applied. Positive identification of the weed was made by Arthur Cronquist of the New York Botanical Garden (personal communication). Herbarium specimens of calico aster at Louisiana State University date back to 1889. Two other asters collected in and around sugarcane fields were identified as *A. praealtus* Poir. var. nebraskensis (Britton) Wiegand, a perennial with short rhizomes, and *A. subulatus* Michx. var. ligulatus Shinners (=*A. exilis*), an annual. *A. praealtus* apparently is not widespread, but *A. subulatus* is widely distributed in southern Louisiana although it has not become an important weed of sugarcane because it is controlled by standard herbicide treatments.

Calico aster is a perennial plant that occurs widely in the eastern half of the United States and generally is described as inhabiting low meadows and woodlands, but it has not previously been reported as a weed of cultivated crops. The growth habit of calico aster in Louisiana sugarcane fields has been observed for several years and a general description of the plant is presented here. Plants flower profusely beginning in October, and seed generally are produced from November through December. A large amount of seed is produced by the composite flowers and the seed is distributed locally by wind. These seed apparently germinate soon after dispersal, when moisture is available, and large numbers of seedlings can be found around older plants in December and January. Older plants also initiate new growth from basal crown buds in December and January. Both the ratoons and seedlings have been observed to withstand temperatures of -10 C, although plants generally are partially protected by the surrounding grass mulch. The initial growth of the plant in winter is in the form of a rosette which changes to more upright and rapid growth as temperatures increase in late winter. Plants grow to about 1.5 m in height and are generally bushy in appearance; a typical infestation in a ratoon sugarcane field is shown in Figure 1.

Figure 1. Infestation of calico aster in a ratoon sugarcane field.

The question of why calico aster, an indigenous plant, "suddenly" became a weed of sugarcane probably can be explained by two related events. First, in the late 1960's, sugarcane growers began using MSMA (monosodium salt of methylarsonic acid) to control johnsongrass on ditchbanks. Over a period of several years, this treatment controlled johnsongrass [Sorghum halepense (L.) Pers.] and allowed bermudagrass [Cynodon dactylon (L.) Pers.] to become the dominant vegetation on ditchbanks (3). Calico aster probably cannot become established on ditchbanks heavily infested with johnsongrass but did become established on ditchbanks infested with bermudagrass. These ditchbanks, which occupy about 10% of the area of sugarcane fields, serve as a natural reservoir from which the wind-dispersed seed can be distributed to adjacent fields. Second, the initial establishment of calico aster in ratoon fields was aided by the widescale use of 2,4-D which has been shown to be ineffective for the control of aster (5).

The research reported here was designed to evaluate herbicide treatments for the control of calico aster and the complex of other winter weeds that grow in sugarcane fields.

MATERIALS AND METHODS

Five experiments, involving one to several field studies each, were conducted during the period 1976 to 1985; aster studies were near Houma, Louisiana, and other winter weed studies were near Houma, Breaux Bridge and Lockport, Louisiana. Treatments in individual studies were arranged in replicated, randomized complete block designs on either silt loam or silty clay loam soils having about 1.5% organic matter. For aster studies, plots were one row wide by 12 to 15 m long; for other studies plots were 3 rows wide by 14 m long. Rows consisted of standard raised sugarcane beds spaced 1.7 m apart in which aster plants and/or sugarcane plants were established on top of the beds.

Herbicides were applied in water with a tractor-mounted sprayer calibrated to deliver a broadcast volume of 374 l/ha; a 91 cm band, or about half of the row width, was treated so that all weed leaves were wet. The sides of beds and water furrows were cultivated periodically with standard disc plows to control weeds, and plots were fertilized annually with 112 kg/ha of N.

Commercial formulations of the following herbicides were used in these studies: amine salt of 2,4-D [(2,4-dichlorophenoxy)acetic acid], amine salt of dicamba (3,6-dichloro-2-methoxybenzoic acid), amine salt of triclopyr [(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid, low volatile ester of silvex [2-(2,4,5-trichlorophenoxyl)propionic acid], potassium salt of picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid), sodium salt of asulam [(methyl[(4-aminophenyl)sulfonyl]carbamate)], atrazine [(6-chloro-N-ethyl-N-(1-methylethyl)-1,3,5-triazine-2,4-diamine)], metribuzin [(4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one)], terbacil [(5-chloro-3-(1,1-dimethylethyl)-6-methyl-2,4(1H,3H)-pyrimidinedione], sodium salt of fenac (2,3,6-trichlorobenzeneacetic acid) and hexazinone [(3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione)]. Rates for 2,4-D, dicamba, fenac, picloram, triclopyr and silvex were based on the acid equivalent; that for other herbicides were based on the active ingredient. A nonionic surfactant at either 0.13 or 0.25% v/v was added to all herbicide solutions unless indicated otherwise.

Experiment 1, established to evaluate the systemic herbicides dicamba, silvex, triclopyr, picloram, and asulam for control of calico aster, was conducted in two field studies, one in 1976 with two replicates per treatment and another in 1977 with three replicates per treatment. The 1976 study was conducted in a sugarcane field in which a natural infestation of aster had developed following the germination of seed, probably in December. The infestation varied from 200 to 1000 plants per plot; the plants grew on the sides of beds and thus probably were not greatly affected by sugarcane competition until late in the growing season. They were about 35 cm tall when herbicide treatments were applied on April 9. In the 1977 study, aster seedlings were transplanted on April 1 from the greenhouse to the field at a spacing of 0.3 m, with each plot having 36 plants (no sugarcane was planted). Herbicide treatments were applied on May 19. In both studies, plants had developed a basal bud zone and thus were perennial when treated. Injury ratings for viable plants were made 60 days after treatment. Percent kill of plants was determined from counts in April following overwintering.

Experiment 2, in 1981, was designed to evaluate the effect of herbicide combinations on control of calico aster. The field for experiment 2 had been prepared the previous year (1980) by transplanting potted aster seedlings and potted sugarcane plants (cultivar CP 65-357) in April from the greenhouse to the field at a spacing of 0.3 m for asters and 0.6 m for sugarcane. Thus, two aster plants alternated with one sugarcane plant in the planting furrow. Aster plants were in flower when the sugarcane was harvested in November 1980 and the harvester cut both the sugarcane and aster plants near ground level and removed them from the top of the bed. Aster plants initiated new growth (ratoons) soon after harvest, and these plants were 15 to 45 cm in height when the herbicide treatments were applied on April 15, 1981. Plots were replicated three times. For treatment combinations, plants received an initial application of a herbicide normally used for johnsongrass control and two hours later, a second application of either dicamba or silvex was made. The initial herbicide treatment was either with asulam, a standard postemergence treatment, or with metribuzin, hexazinone or a mixture of terbacil and fenac, standard preemergence treatments. Percent kill was determined in October and during the following March (1982); the maximum number of living plants observed at either date was used in the calculations.

Experiment 3, designed to evaluate the effect of atrazine alone and in mixtures for control of calico aster, was conducted in two studies, one in 1984 with two replicates, and the other in 1985 with three replicates. The fields were prepared one year in advance in the same way as that described for Experiment 2 with the exception that aster and sugarcane plants alternated with each other in the planting furrow at the spacing of 0.3 m. Herbicide treatments were applied on March 30, 1984, or on March 15, 1985, when aster averaged about 30 cm in height. Aster plants were evaluated for injury in June of each year and for kill in August or September.

Experiments 4 and 5 were conducted in commercial sugarcane fields that had natural infestations of winter weeds. The weed species varied in the studies, but the most prevalent weeds were common chickweed, henbit, Carolina geranium and annual canarygrass. One study in Experiment 4 had a heavy infestation of eveningprimrose. Calico aster occurred only sporadically in these studies.

Experiment 4 was established to evaluate atrazine treatments for postemergence control of winter weeds of different sizes. Three field studies (1983-1985), each with three replicates, were conducted in the second-ratoon crop of CP 65-357 sugarcane that had been harvested in November. Herbicide treatments were either applied in the middle of December, shortly after weeds had germinated (weeds were no more than 3 to 5 cm in height) or were applied in late March when weeds were large, ranging from 15 to 30 cm in height and in flower. Treatments were evaluated for weed control in late April.

Experiment 5 was designed to evaluate the effect of early-season control of winter weeds on growth of ratoon crops. Four field studies were conducted: two in 1982 with 5 or 8 replicates, one in 1984 with 6 replicates, and one in 1985 with 12 replicates. The studies were in first-ratoon or second-ratoon crops of CP 65-357 in 1982 and 1984, and on first-ratoon CP 72-356 in 1985; the first ratoon crops had been harvested in December and the second-ratoon crops in November. Following harvest, winter weeds were controlled with a mixture of atrazine at 1.7 and 2,4-D at 1.1 kg/ha applied either shortly after weed germination, during December to February - depending on the study, or after weeds were mature in April. Millable stalks were counted in September and used as a measure of the effects of treatments on growth and yield of sugarcane.

RESULTS AND DISCUSSION

In Experiment 1, the effectiveness of the various herbicide treatments for the control of calico aster is best quantified by considering both the kill of aster plants, as determined one year after treatment, and the injury or stunting of surviving plants during the period following treatment (Table 1). In terms of actual kill, only picloram at 1.1 kg/ha was highly effective, giving 95% kill. Other treatments giving a fair level of kill were triclopyr at 2.2 kg/ha (78%), a mixture of asulam at 3.3 + dicamba at 1.1 kg/ha (72%), a mixture of silvex at 1.1 + dicamba at 1.1 kg/ha (66%), dicamba at 2.2 kg/ha (64%), a mixture of asulam at 3.3 + silvex at 2.2 kg/ha (63%), and triclopyr at 1.1 kg/ha (62%). In terms of overall control, however, all of these treatments, as well as other treatments involving dicamba at 1.1 kg/ha, gave good to excellent control because they severely stunted the growth of aster plants (Table 1). Silvex caused only moderate stunting of plants, and thus was more effective when used in mixtures than when used alone.

Asulam is widely used to control grasses, particularly johnsongrass, in sugarcane, but also is known to be active against some broadleaved weeds of the Compositae, Crucifereae and Polygonaceae (2). In this experiment, asulam at 4.5 kg/ha killed 33% of the aster plants but caused very little stunting (Table 1). It caused leaf desiccation, but surviving plants usually recovered quickly. A mixture of asulam and dicamba would seem to be an excellent spring treatment for controlling a mixed population of aster and johnsongrass.

In Experiment 2, dicamba, silvex and asulam applied alone gave 80, 66 and 57% kill of aster, respectively (Table 2), which was a higher level of kill than that observed from these treatments in Experiment 1 (Table 1). The ratoon plants in this experiment, as compared to plants established from seed in Experiment 1, were apparently somewhat weaker, perhaps because of greater competition from sugarcane and injury from harvesting.

Of the treatments normally used for preemergence or early postemergence weed control in sugarcane, hexazinone applied alone gave about 75% kill of aster as compared to only 18% for either metribuzin or the mixture of terbacil and fenac (Table 2). Both metribuzin and hexazinone caused leaf desiccation, but the injury was much more severe with hexazinone. The mixture of terbacil and fenac caused only a slight stunting of growth.

The performance of dicamba was not greatly improved by the addition of other herbicides (Table 2). The possible exception was the apparent additive effect on control with the use of asulam and dicamba which together gave 91% control as compared to 80% for dicamba alone. The performance of silvex, on the other hand, was improved by the addition of all herbicides except metribuzin which was the least effective herbicide for combination treatments.

Table 1. Comparison of herbicide treatments for postemergence control of nonratoon calico aster (Experiment 1).

Herbicide & rate(kg/ha)1/	Plants killed and injury to surviving plants in two experiments2/					
	1976		1977		Mean	
	Kill3/ (%)	Injury rating (0-10)4/	Kill3/ (%)	Injury rating (0-10)4/	Kill3/ (%)	Injury rating (0-10)4/
Dicamba - 0.6	6	5	33	5	20	5
Dicamba - 1.1	65	8	35	8	50	8
Dicamba - 2.2	78	9	50	9	64	9
Silvex - 1.1	6	2	14	2	10	2
Silvex - 2.2	30	5	23	5	27	5
Triclopyr - 1.1	75	8	48	8	62	8
Triclopyr - 2.2	93	9	62	9	78	9
Picloram - 1.1	99	9+	90	9+	95	9+
(Silvex - 1.1 +dicamba - .06)	15	8	44	8	30	8
(Silvex - 1.1 + dicamba - 1.1)	79	9	53	9	66	9
Asulam - 4.5	20	2	46	2	33	2
(Asulam - 3.3 + dicamba - 1.1)	65	8	78	8	72	8
(Asulam - 3.3 + silvex - 1.1)	55	4	59	4	57	4
(Asulam - 3.3 + silvex - 2.2)	50	5	76	5	63	5

1/ Applied with a 0.13% v/v nonionic surfactant.

2/ The experiment in 1976 was on a natural infestation of calico aster in sugarcane; the one in 1977 was on a space-planted infestation in a weed nursery.

3/ Death of plants was determined after overwintering, about one year following treatment.

4/ Injury ratings, made 60 days after treatment, were based on: 0 - none; 1, 2, 3 - slight; 4, 5, 6 - moderate; 7, 8, 9 - severe; 10 - all dead.

Table 2. Postemergence control of ratoon calico aster in sugarcane with combinations of herbicides1/ (Experiment 2, 1981)

Herbicide treatments (kg/ha) that control johnsongrass and other weeds in sugarcane	Aster plants killed2/		
	Systemic herbicide treatments (kg/ha) that control broadleaved weeds		
	None	Dicamba - 1.13/	Silvex - 2.23/
	(%)		
None	5	80	66
(Terbacil - 1.5 + fenac-2.0)	18	78	84
Metribuzin-2.2	18	67	65
Hexazinone-1.2	75	85	89
Asulam-3.73/	57	91	87

1/ Herbicides in combinations were applied sequentially on April 15.

2/ Control for each treatment was determined from the maximum number of plants that survived, either in October following treatment or in March after overwintering.

3/ Applied with a 0.25% v/v nonionic surfactant.

In Experiment 3, atrazine applied alone gave about 50% kill of ratoon aster plants and caused moderate injury to surviving plants in terms of leaf desiccation and stunting of growth (Table 3). In comparison, terbacil, metribuzin and 2,4-D did not kill any plants, although metribuzin caused moderate injury. Dicamba was the most effective herbicide for controlling aster, giving a high level of control whether applied alone at 1.1 kg/ha or when applied at 0.6 and 0.8 kg/ha in mixtures with atrazine or 2,4-D. All herbicides gave relatively good control of other winter weeds which included cressleaf groundsel (Senecio glabellus Poir.), Philadelphia fleabane (Erigeron philadelphicus L.), horseweed [Conyza canadensis (L.) Cronq.], and Carolina geranium (Table 3). Dicamba and 2,4-D, however, did not provide effective control of woodsorrel (Oxalis sp.) or prostrate spurge (Euphorbia sp.) and thus the overall control of broadleaved weeds by these two herbicides was not as effective as that obtained with atrazine. The lack of control of prostrate spurge by dicamba and 2,4-D apparently reflects the lack of residual control, since seed probably germinated shortly after treatments were applied in March.

In an unreported study, we observed that preemergence treatments of atrazine at 1.6 kg/ha or metribuzin at 0.9 kg/ha gave almost perfect control of aster seedlings that germinated in late fall. Terbacil at 0.9 kg/ha also gave good control but was somewhat less effective than atrazine and metribuzin.

Table 3. Comparison of atrazine alone and in mixtures with other herbicides for postemergence control of ratoon calico aster and other weeds in sugarcane (Experiment 3).

Herbicide & rate (kg/ha)1/	Aster kill and injury to surviving plants: 1984 study Kill2/ (%)	1985 study Kill2/ (%)	1985 study Injury rating (0-10)3/	Control of other winter & summer broadleaved weeds in 1985 study4/ (%)
Atrazine - 1.8	59	46	6	99
Metribuzin - 1.8	--	0	4	98
Terbacil - 1.8	--	0	0	100
2,4-D - 2.2	--	0	0	85 5/
Dicamba - 1.1	100	100	10	85 5/
(Atrazine - 1.8 + 2,4-D - 1.7)	--	41	6	99
(Atrazine - 1.8 + dicamba - 0.6)	100	100	10	99
(Atrazine - 1.8 + dicamba - 0.8)	100	100	10	99
(2,4-D - 1.7 + dicamba - 0.6)	--	95	9+	85 5/
(2,4-D - 1.7 + dicamba - 0.8)	--	100	10	85 5/

1/ Applied in March with a 0.25% v/v nonionic surfactant.

2/ Kill was based on the number of living and dead plants in August of the year treated.

3/ An injury rating was made in June based on: 0 - none; 1, 2, 3 - slight; 4, 5 6 - moderate; 7, 8, 9 - severe; 10 - all dead.

4/ Winter broadleaved weeds primarily consisted of cressleaf groundsel, Philadelphia fleabane, Carolina geranium, and horseweed; spring-summer broadleaved weeds primarily were woodsorrel and spurge.

5/ Woodsorrel and prostrate spurge were not controlled effectively.

In Experiment 4, atrazine at 1.7 or 2.8 kg/ha, applied either alone or with 2,4-D, was very effective for the postemergence control of the complex of winter weeds which included eveningprimrose (in one study), henbit, chickweed, Carolina geranium, annual canarygrasses, and others (Table 4). The treatments were only slightly more effective on the very small weeds when compared to the response on

larger weeds which was surprising because atrazine is usually most effective when applied as a preemergence or very early postemergence treatment. These winter weeds apparently are quite sensitive to atrazine and are affected from both shoot and root absorption.

Table 4. Postemergence control of winter weeds in ratoon sugarcane with atrazine and other herbicide treatments (Experiment 4).

Herbicide & rate (kg/ha)1/	Control by treatment date and weed size: Applied in December to small seedling weeds2/	Applied in March to large maturing weeds3/
	(%)	
Atrazine - 1.7	97	91
Atrazine - 2.8	99	94
(Atrazine - 1.7 + 2,4-D - 1.1)	99	95
(Atrazine - 1.7 + 2,4-D - 2.2)	--	96
2,4-D - 1.1	47	--
2,4-D - 2.2	--	75
(2,4-D - 1.7 + dicamba - 0.6)	--	82

1/ Applied with a 0.25% v/v nonionic surfactant.

2/ Average of two experiments in 1983-1984. In one experiment the weed complex consisted of eveningprimrose and other broadleaved weeds and, a mixture of grassy weeds, including annual canarygrass. In the other experiment weeds consisted primarily of a complex of chickweed, henbit, Carolina geranium, and annual canarygrasses.

3/ Data from one experiment in 1985 in which weeds were a mixture of chickweed, henbit, Carolina germanium and annual canarygrasses.

Atrazine has the advantage over 2,4-D or dicamba in that it will control both winter broadleaved weeds and several common winter grasses such as the annual canarygrasses, but observation has shown that it will not provide postemergence control of ryegrass (Lolium sp.) which is not a common weed of sugarcane at present. Calico aster was not abundant in these studies but a mixture of atrazine and dicamba would be an effective treatment for mixed populations of aster and winter weeds (Table 3).

Experiment 5 showed that this complex of winter weeds is capable of adversely affecting growth of ratoon sugarcane (Table 5). The number of millable stalks produced at harvest was about 7% higher when weeds were controlled in winter rather than in spring. Similar results were observed when weeds were allowed to compete with fall-planted sugarcane during winter before being removed in March (4).

Table 5. Effect of early-season control of winter weeds on production of millable stalks by ratoon sugarcane crops (Experiment 5)1/

Time of weed control2/	Millable stalks/ha by year of experiment4/,5/: 1982	1982	1984	1985	Mean
			(No.)		
Winter (Dec. to Feb.)	89,300 a	85,600 a	89,000 a	90,700 a	88,700 a
Spring (Apr.)3/	81,400 b	80,400 b	83,200 b	86,700 b	82,900 b

1/ Weeds primarily consisted of a complex of chickweed, henbit, Carolina geranium and annual canarygrass.

2/ Weeds were controlled with a mixture of atrazine - 1.7 + 2,4-D - 1.1 kg/ha + a 0.25% nonionic surfactant.

3/ Represents latest period that weeds would normally survive in commercial sugarcane fields because of herbicide treatment and natural senescence.

4/ Means within a column followed by the same letter are not significantly different at the 5% level of probability as determined by the Duncan's multiple range test.

5/ Sugarcane was the second-ratoon crop of CP 65-357 in 1982 and 1984 and the first-ratoon of CP 72-356 in 1985. Millable stalk counts were made in September before harvest in November or December.

In Louisiana, winter weeds are routinely controlled with preemergence herbicide treatments in plant cane, but not in ratoon cane. In ratoon cane, broadleaved winter weeds may be controlled with phenoxy herbicides in late winter but frequently are not controlled until spring when preemergence treatments for johnsongrass control are applied. This study indicates that a more routine use of herbicides to control winter weeds in ratoon crops is warranted. The use of early postemergence treatments rather than preemergence treatments would allow selection of fields for treatment and thus would be the most economical method of treatment.

The recent registration of dicamba for use in sugarcane should be of great value in controlling calico aster. However, this weed probably will continue as part of the weed flora in fields, thus preventing the return to 2,4-D for control of winter-growing broadleaved weeds. Calico aster has not been controlled as effectively on ditchbanks as it has in fields, and the use of more effective treatments would probably reduce aster populations further. MSMA, which is widely used to control johnsongrass on ditchbanks, does not effectively control aster, and a mixture of MSMA and dicamba would increase control. Other herbicides may be registered that also will effectively control both weeds and yet leave the bermudagrass cover that helps prevent erosion.

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SUGARCANE CROP DAMAGE AND YIELD LOSS FROM HURRICANE FORCE WINDS

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ABSTRACT

Hurricane Danny was near or over the southwest coastal areas of Louisiana from August 14 to 16, 1985, causing extensive damage to sugarcane (Saccharum interspecific hybrids) and other crops. Following the storm field surveys in Iberia and Lafayette Parishes were made in seven commercial varieties to determine the number and percentage of broken stalks; these data were also used to estimate yield loss for three varieties, CP 65-357, CP 72-356 and CP 74-383, one to four months after the storm. The percentage of broken stalks for these three varieties were 17.8, 73.0 and 7.4 percent, respectively. Yield losses were calculated on the basis of the weighted averages for experimentally determined stalk weights and juice analyses for both broken and unbroken stalks of each of the three varieties. The percentage of breakage was related to important reductions in yields of cane per hectare, sugar per ton and sugar per hectare as well as changes in fiber content between broken and unbroken stalks. One month after the storm, yield loss in sugar per hectare was closely related to the loss of cane per hectare as sugar per ton in both broken and unbroken stalks was similar; however, with increasing time after the storm, losses in sugar per ton became more accentuated as unbroken stalks reached maturity.

INTRODUCTION

Crop damage from hurricane force winds has always been one of the hazards of growing sugarcane (Saccharum interspecific hybrids) in Louisiana. Breakage of stalks is the most common form of damage; however, the actual level of broken stalks and, consequently, yield loss will vary greatly depending upon varieties and the environment (1,2,4,7,8).

Following a tropical storm with winds of 40 to 80 km h^{-1} in Louisiana, Hebert and Arceneaux (7) noted that there were differences among varieties in the number and percentage of millable stalks broken. They found that the extent of breakage varied from 0.5 percent of the total millable stalks for a wind-resistant to 21 percent for a wind-susceptible variety. However, Arceneaux (1) noted that for accurate appraisals of the economic importance of varietal susceptibility to wind damage, it is necessary to know how such damage affects maturity of the broken stalks. He reported that broken stalks of both plant cane and first stubble (ratoon) cane matured in a near normal manner; however, broken stalks were distinctly inferior to undamaged stalks in indicated yield of 96° sugar per ton of cane. The data indicated a decrease in sugar per ton of 4 to 34 percent in the plant cane crop and 13 to 28 percent in the first ratoon crop as an average of three varieties from one to four months following the storm.

In a subsequent study, Arceneaux et al. (2) simulated the effects of hurricane force winds by artificially breaking the tops of millable stalks of three varieties. For each variety, they broke 0, 20, 40, 60, 80 and 100 percent of the stalks that would be expected to reach maturity. Average reductions in yield of sugar per hectare ranged from 9.7 percent, when 20 percent of the stalks were broken, to 54.1 percent, when all stalks were broken. The results reflected a reduction in quality as well as quantity of cane produced. Further, there were significant differences in response among varieties within the range of 20 to 60 percent breakage; however, reductions in yield were similar at breakage levels of 80 and 100 percent.

Following the hurricane of August 14 to 16, 1985, field surveys in Iberia and Lafayette Parishes of southwest Louisiana indicated considerable damage to millable stalks of sugarcane. The purposes of this study were to: 1) determine varietal differences in the number of millable stalks broken; and, 2) to estimate yield loss over time after the storm.

MATERIALS AND METHODS

Field surveys were made in Iberia and Lafayette Parishes on September 11, approximately one month following the storm to determine varietal differences in the number of broken stalks for seven commercial varieties. These included CP 65-357,

CP 70-321, CP 72-356, CP 72-370, CP 74-383, CP 76-331 and NCo 310. For each variety, three plots were randomly selected within the same field or block of cane with each plot measuring 3 rows (5.4 m) by 4.9 m long. The total number of millable stalks was counted for each plot and recorded. Then the number of broken stalks was counted and recorded; all broken stalks and those bent at least 90 degrees were counted and recorded as broken. The proportion of unbroken and broken stalks in the total plot population was then calculated.

To estimate yield losses over time after the storm, three varieties (CP 65-357, CP 72-356 and CP 74-383) were selected based on their proportion (percent) of millable stalks broken. CP 72-356 had the greatest percent of broken stalks, CP 74-383 the lowest and CP 65-357 had an intermediate level of broken stalks. Duplicate or triplicate 15-stalk samples of both unbroken and broken stalks of two varieties, CP 65-357 and CP 72-356, were taken on each of four monthly sampling dates beginning September 11 and ending December 6. For the third variety, CP 74-383, samples were taken until November 15, after which the fields were harvested for the mill. All samples were taken from the same fields or blocks where the surveys were made. Samples of unbroken stalks were cut at ground level and topped approximately 6 cm below the growing point. Samples of broken stalks were cut only at ground level. No leaves or lateral shoots were removed from either sample. All samples were transported to the Houma Laboratory for specific measurements and juice analyses. Each sample was weighed, and individual stalks were measured for length. Observations on the presence of lateral shoots were recorded. Stalks were crushed once through a 3-roll sample mill (approximately 50 percent extraction by weight of sample) and, after thorough mixing, a subsample of crusher juice was removed and analyzed by standard methods. Data obtained included brix by hydrometry and apparent sucrose (as percent of juice) by polarimetry (3). The yield of theoretical recoverable sugar per ton of cane (9) was calculated. On the last sampling date, fiber content was determined for two of the three varieties, CP 65-357 and CP 72-356, for both broken and unbroken stalks using the press method (11). No leaves, tops or lateral shoots were removed prior to sample preparation by a cutter-grinder.

On each sampling date, estimated yields were calculated, assuming no broken stalks, for the three varieties, CP 65-357, CP 72-356 and CP 74-383, for tons cane per hectare (TC/ha), sugar per ton of cane (S/T) and sugar per hectare (S/ha), using the following formulas:

$$\text{I.} \quad TC/ha_1 = \frac{374\ P(W)}{2205}$$

where TC/ha_1 = tons cane per hectare with no broken stalks, 374 = constant used to convert to hectare basis, P = total millable stalk population per plot, W = average weight in pounds of unbroken millable stalks and 2205 = pounds per metric ton.

$$\text{II.} \quad S/T_1 = (s_c x)-(b_c y)$$

where S/T_1 = 96 pol sugar per ton with no broken stalks, s_c = number of 1 percent increments of sucrose in crusher juice of unbroken stalks, x = sucrose factor, b_c = number 1 percent increments of brix in crusher juice of unbroken stalks and y = brix factor.

$$\text{III.} \quad S/ha_1 = (TC/ha_1)(S/T_1)$$

Estimated yields were also calculated on each sampling date for each variety based on the proportion of unbroken and broken stalks per hectare according to the following formulas:

$$\text{IV.} \quad TC/ha_2 = \frac{374\quad P[n \cdot W_1+(1-n) \cdot W_2]}{2205}$$

where TC/ha_2 = tons cane per hectare with broken stalks, P = total millable stalk population per plot, n = proportion of unbroken stalks, W_1 = average weight in pounds of unbroken millable stalks, (1-n) = proportion of broken millable stalks and W_2 = average weight in pounds of broken millable stalks.

$$\text{V.} \quad S/T_2 = n[(s_{c1}x)-(b_{c1}y)]+(1-n)[(s_{c2}x)-(b_{c2}y)]$$

where S/T_2 = 96 pol sugar per ton with broken stalks, n = proportion of unbroken stalks, s_{c1} = number of 1 percent increments of sucrose in crusher juice of unbroken stalks, x = sucrose factor, b_{c1} = number of 1 percent increments of brix in crusher

juice of unbroken stalks, y = brix factor, (1-n) = proportion of broken stalks, s_{c_2} = number of 1 percent increments of sucrose in crusher juice of broken stalks and b_{c_2} = number of 1 percent increments of brix in crusher juice of broken stalks.

$$\text{VI.}\quad S/ha_2 = (TC/ha_2)(S/T_2)$$

Yield losses were then calculated as the difference between the estimated yield with no broken stalks and the estimated yield with broken stalks.

For all variables the "t" test of significance was used for mean separation (6).

RESULTS AND DISCUSSION

Following the hurricane of August 14 to 16, 1985, sugarcane was severely lodged by the storm and damage reports from the southwest coastal parishes of Iberia, Lafayette, St. Martin and Vermilion indicated that a considerable proportion of tops had been broken in most commercial varieties, particularly CP 65-357 and CP 72-356. However, following the storm with winds of 90 to 110 km h^{-1}, the cane recovered rapidly, and within one to two weeks after the storm the lodging was much less apparent.

The proportion (percentages) of broken stalks at two locations in the plant cane crops of seven commercial varieties is shown in Table 1. Among the varieties examined, CP 72-356 which occupied approximately 10 percent of the state sugarcane acreage in 1985 (5) suffered the greatest damage with an average of 73 percent of its estimated millable stalks broken. At each of the two locations, CP 72-356 had more broken stalks than any other variety investigated. Although there appeared to be a location by variety interaction, CP 76-331, released for commercial use in 1984, as an average of both locations, had the second greatest proportion of millable stalks broken (23%). CP 65-357 and CP 70-321 with 29 and 38 percent of the state sugarcane acreage, respectively, had 18 and 13 percent of their millable stalks broken. The remaining variety common to both locations, CP 74-383, had only 7.4 percent of its stalks broken; however, both CP 72-370 and NCo 310 had lower levels at only the one location reported. NCo 310 with only a trace acreage in the state had less than 1 percent of its stalks broken.

Table 1. Proportion (percent) of millable stalks of seven commercial varieties in the plant cane crop broken by hurricane force winds at two locations in Louisiana, August 14 to 16, 1985[1/].

Variety	Iberia Parish[2/]	Lafayette Parish[3/]	Average
	-----------	%	-----------
CP 65-357	21.0	14.6	17.8
CP 70-321	8.1	18.4	13.2
CP 72-356	83.5	62.5	73.0
CP 72-370	3.2	---	---
CP 74-383	12.5	2.3	7.4
CP 76-331	13.1	32.3	22.7
NCo 310	---	0.2	---

1/ Based on estimated number of millable stalks taken September 11, 1985.
2/ Peebles Plantation, Sterling Sugars, Inc., Franklin, Louisiana.
3/ Triple-V Farms, Inc., Youngsville, Louisiana.

Arceneaux et al. (2) reported that stalk breakage caused by high winds was largely confined to a region of immature joints immediately below the growing point. One month after the storm the percentage loss in stalk length among the three varieties, CP 65-357, CP 72-356 and CP 74-383, was essentially the same (Table 2). However, with continued growth in unbroken stalks there appeared an increase in the percentage loss among the three varieties in stalk length between unbroken and broken stalks at two months after the storm.

Table 2. Stalk length in broken and unbroken stalks of three commercial varieties in the plant cane crop affected by hurricane force winds at two locations from one to two months after the storm in Louisiana, August 14 to 16, 1985.

Variety	Iberia Parish1/			Lafayette Parish2/			Avg.
	U3/	B	D	U	B	D	loss
	(cm)	(cm)	(%)	(cm)	(cm)	(%)	(%)
CP 65-357							
1 month4/	144.8	105.9	26.8*	172.2	111.8	35.1	30.9*
2 months	184.5	95.4	48.3*	228.1	112.1	50.9	49.6*
CP 72-356							
1 month	136.1	82.8	39.2*	169.4	129.8	23.4	31.3*
2 months	152.8	85.0	44.4*	193.9	129.6	33.2	38.8*
CP 74-383							
1 month	148.6	107.2	27.9*	162.3	113.0	30.4	29.1*
2 months	181.8	101.9	43.9*	184.4	103.4	43.9	43.9*

1/ Peebles Plantation, Sterling Sugars, Inc., Franklin, Louisiana.

2/ Triple-V Farms, Inc., Youngsville, Louisiana.

3/ U = Unbroken; B = Broken; and, D = Percent difference between unbroken and broken stalks.

4/ Sampling dates: 1 month = September 11; and, 2 months = October 17.

* Indicates significant differences from unbroken stalks at P = 0. 05, using t-test.

According to Arceneaux et al. (2) the development of lateral shoots for three varieties was affected by varietal differences and the percentage of broken stalks. In this study CP 72-356 had the highest percentage of broken stalks (Table 1) and the highest level of lateral shoots--an average of 1.6 live lateral shoots per broken stalk (data not shown) while both CP 65-357 and CP 74-383 had less than a third of the live lateral shoots of CP 72-356. The lateral shoots appearing on CP 72-356 were developing mature internodes by three months after the storm, whereas, the lateral shoots found on CP 65-357 and CP 74-383 were mostly spindly and dying. No lateral shoots were evident on any of the unbroken stalks of all three varieties.

Stalk breakage had an immediate effect on stalk weight (data not shown); however, a significant reduction in cane tonnage in the first month occurred in only one variety, CP 72-356 (Table 3). For the remaining two varieties, a significant loss in cane tonnage was not measured in the first three months after the storm. Besides the loss in cane tonnage due to stalk breakage, Davidson and Irvine (4) noted that cane left in the field as scrap adds considerably to the overall loss. In this study the short broken stalks of CP 65-357 and CP 74-383 would presumably be lost while the stalks of CP 72-356 would be saved.

The loss in sugar per ton increased as the percentage of breakage increased (Table 3). Also, the difference in sugar content between broken and unbroken stalks became significantly more pronounced with time after the storm. This indicates that broken stalks matured less than did the undamaged ones. It is also interesting to note that one month after the storm, the losses in sugar per ton were not significant for any of the three varieties. In view of the extensive damage to stalks, particularly in CP 72-356, the sugar content of broken stalks is worthy of note. While the observed differences in sugar content between broken and unbroken stalks may not reflect accurately the actual loss of sugar suffered as a result of such breakage, the indicated yield of sugar per ton in damaged cane was much more satisfactory than might have been anticipated.

In order to evaluate the extent of sugarcane crop damage and to estimate the loss in sugar yields caused by high winds of hurricanes, Moore and Osgood (10) developed a model in Hawaii for estimating sugar loss based on 1) stalk growth termination; 2) metabolic depletion; and 3) reduced assimilation. However, in this study only stalk growth termination (stalk breakage) was measured; therefore, their model could not be tested.

The average loss in the yield of sugar per hectare was in line with the loss in cane tonnage and in sugar per ton with time after the storm (Table 3). Arceneaux et al. (2) reported that a rough estimate of loss in the yield of sugar per hectare

from breakage could be obtained by dividing the percentage of breakage by 2. In the present study, the estimate would have been more satisfactory two or more months after the breakage occurred than before; at one month after the storm, the losses in sugar per acre would have been grossly over-estimated. Although the losses in sugar per hectare stabilized two months after the damage occurred, this might change with the date of the storm, the variety, the extent of damage, and the harvest date after the storm.

Table 3. Yield losses of three commercial varieties in the plant cane crop due to hurricane force winds at two locations from one to four months after the storm in Louisiana, August 14 to 16, 1985.

Variety	Losses1/		
	TC/ha2/	S/T	S/ha
	%		
CP 65-357			
1 month	3.7 NS	0.0 NS	3.7 NS
2 months	7.3 NS	4.4 NS	10.0 NS
3 months	7.8 NS	3.6 NS	9.4 NS
4 months	7.9 *	3.6 *	10.6 *
CP 72-356			
1 month	21.0 *	4.6 NS	24.5 *
2 months	21.7 *	9.6 *	28.8 *
3 months	23.0 *	11.0 *	30.5 *
4 months	19.9 *	11.0 *	27.4 *
CP 74-383			
1 month	1.6 NS	(1.0)NS	1.5 NS
2 months	2.3 NS	1.5 NS	3.3 NS
3 months	5.9 NS	3.8 NS	8.0 NS
4 months	---	---	---

1/ Combined analyses for two locations at one and two months after storm for all varieties, and at three months for CP 72-356 only; individual analyses for remaining results.

2/ TC/ha = Tons cane per hectare; S/T = Sugar per ton; S/ha = Sugar per hectare.

* Indicates significant differences from estimated yields based on unbroken stalks only, P = 0.05, using t-test.

Significant differences in fiber content were observed between broken and unbroken stalks of CP 65-357, while no difference was noted for CP 72-356 four months after the storm (Table 4). This difference between CP 65-357 and CP 72-356 was due to the large number of lateral shoots found on CP 72-356. In many cases these lateral shoots had developed from one to three mature joints and would add both additional stalk fiber and trash. Consequently, broken stalks of CP 72-356 approached normal fiber content. In CP 65-357, where the difference in fiber content between broken and unbroken stalks exceeded 33 percent, the estimate of sugar per ton of cane would be biased when comparing broken and unbroken stalks on the basis of juice analysis alone (2).

Table 4. Fiber content in broken and unbroken stalks of two commercial varieties in the plant cane crop affected by hurricane force winds on December 6 after the storm in Louisiana, August 14 to 16, 1985.1/

Variety	U2/	B	D
	%		
CP 65-357	14.06	9.31	33.8*
CP 72-356	11.79	10.80	8.4

1/ Each value in table is the average of three replications; Triple-V Farms, Inc., Youngsville, Louisiana.

2/ U = Unbroken; B = Broken; and D = Percent difference between unbroken and broken stalks.

* Indicates significant differences from unbroken stalks at P = 0.05, using t-test.

SUMMARY

In summary, the average percentage of stalk breakage in the plant cane crop was dependent upon the variety and ranged from a low of less than 1 percent breakage in NCo 310 to a high of over 73 percent breakage in CP 72-356. For three varieties, CP 65-357, CP 72-356 and CP 74-383, the proportion of stalk length lost in breakage was similar. Average reductions in yield of cane and sugar per hectare were dependent on the percentage of broken stalks and, to a lesser extent on the reduction in sugar per ton as the cane matured. To appraise the total loss, the damage to the total millable stalk population has to be considered rather than to individual stalks due to the changes in development and quality of both broken and unbroken stalks.

Broken stalks of one variety, CP 65-357, had an abnormally low fiber content while in CP 72-356 the fiber content was similar between broken and unbroken stalks.

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CONTROL OF EQUISETUM HYEMALE ON DRAINAGE DITCHES IN SUGARCANE

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ABSTRACT

Equisetum hyemale L. (scouringrush), which spreads primarily by rhizomes, began a noticeable invasion of drainage ditches in Louisiana sugarcane fields along Bayou Lafourche and the lower Mississippi River during the 1970's. Its spread was apparently enhanced by the widescale use of MSMA to control johnsongrass on these ditches. MSMA treatments effectively eliminated johnsongrass and allowed scouringrush to spread without major competition. Field studies on the typical silt loam and loam habitats showed that scouringrush was controlled 80 to 100% with tebuthiuron at about 17 kg/ha, hexazinone at about 17 kg/ha or bromacil at about 28 kg/ha. These herbicides are soil-active and the high rates were required for consistent control of scouringrush's extensive rhizome system. A foliage-active herbicide, chlorsulfuron, at about 0.6 kg/ha gave, on average, 74% to 92% control, but control tended to be variable within experiments. Single treatments with either the soil-active herbicides or with chlorsulfuron seldom gave complete control, and follow-up treatments would be needed to prevent reinfestation. The eradication of new infestations as they occur would prevent the rhizomes from spreading to infest entire ditches.

INTRODUCTION

Scouringrush (*Equisetum hyemale* L. = *E. prealtum* Raf.) is a spore-producing plant that grows in moist soil and spreads primarily by an extensive system of long black rhizomes, although it is capable of spreading by spores. The cylindrical evergreen stems, reaching a height of about 1.3 m, have hollow internodes and minute scalelike leaves. The plant stores silica in the stem and at one time was used to scour metal utensils; thus, the name "scouringrush" which has been chosen as a common name by the Weed Science Society of America. Locally, it is also called "poppinggrass".

This species is widely distributed in the U.S., occurring in moist soil along streams, ditches, etc. It has not been reported as a weed of crops, as has *E. arvense*, but it has been reported as a weed of field drainage ditches, roadsides and railroads (2, 5). It began a noticeable invasion of drainage ditches in sugarcane fields of southern Louisiana in the 1970's during the same period that MSMA (monosodium salt of methyl arsonic acid) was being used extensively to control johnsongrass [*Sorghum halepense* (L.) Pers.] on these ditches (4). This removal of johnsongrass competition apparently allowed existing small infestations of scouringrush to spread by rhizomes and become the dominant vegetation on some ditches. Scouringrush grows on the banks and in the channels of ditches (Figure 1), and the heavy growth, impeding drainage, requires frequent cleaning of ditch channels. Observations from excavations on ditchbanks indicate that rhizomes generally are concentrated in the upper 30 cm of soil with some rhizomes occurring to depths of at least 45 cm.

In sugarcane plantations, the heaviest infestations of scouringrush usually occur on central ditches which are relatively deep permanent ditches that serve to drain entire farms through the connecting large number of shallow field ditches. Field ditches, which occupy about 10 percent of the area of fields and serve to drain individual fields of one to three acres, also frequently become infested. Field ditches are semipermanent but may be plowed and reditched at intervals as part of the standard cultural practices in sugarcane.

Initial research on controlling scouringrush in drainage ditches in sugarcane evaluated several foliage-active and soil-active herbicides (5). The foliage-active herbicides asulam (methyl[4-aminophenyl)sulfonyl]carbamate), glyphosate [*N*-(phosphonomethyl)glycine], amitrole (1*H*-1,2,4-triazon-3-amine), and picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid) did not give effective control. More promising were the soil-active herbicides bromacil [5-bromo-6-methyl-3-(1-methylpropyl)-2,4(1*H*,3*H*)pyrimidinedione], tebuthiuron (*N*-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-*N*,*N*'-dimethylurea) and hexazinone [3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1*H*,3*H*)-dione]. The present studies were initiated to further evaluate these soil active treatments and also to evaluate chlorsulfuron (2-chloro-*N*-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]benzenesulfonamide), a relatively new foliage-active herbicide (3).

Figure 1. Typical infestation of scouringrush on drainage ditches in sugarcane:
Top - field ditch Bottom - central ditch

MATERIALS AND METHODS

Four experiments, involving one or two studies each, were conducted from 1975 to 1985 on drainage ditches in Louisiana sugarcane fields which were heavily infested with scouringrush. Treatments, arranged in randomized complete block designs with three replicates, were applied to plots 14 to 15 m long and usually included two ditch banks and the bottom of the ditch channel, or, infrequently, one ditchbank and the bottom of the channel when the opposite bank was inaccessible by tractor. The drainage ditches were either field ditches which were about 4 m wide with channels about 1 m wide and 0.6 m deep, or central ditches which were about 8 m wide with v-shaped channels that were 3 to 4 m deep and which ranged in width from 1.5 m at the bottom to 4.5 m at the top. Soil characteristics, as determined by a commercial laboratory on coded samples, are shown in Table 1.

Table 1. Chemical and physical characteristics of ditchbank soil to a depth of 30 cm.

Experiment	Year begun	Texture	pH	Organic matter (%)	Cation exchange capacity (meq/100 g)	Particle size analysis Sand (%)	Silt (%)	Clay (%)
Exp. 1	1975	Silt loam	7.1	1.8	14	21	55	24
Exp. 2	1976	Silt loam	7.7	1.5	17	22	54	24
Exp. 2	1977	Loam	6.7	1.2	15	22	49	29
Exp. 3	1981	Loam	6.5	1.4	18	26	45	29
Exp. 3	1984	Loam	7.5	1.4	18	24	48	28
Exp. 4 & 5	1982	Silt loam	6.9	1.4	12	22	54	24

Commercial formulations of herbicides were used in the studies, but rates are expressed as the amount of active ingredient applied per ha of land. Most herbicides were formulated as wettable powders and were applied as water suspension with a tractor-mounted boom sprayer calibrated to deliver 560 l/ha. A 0.25% v/v nonionic surfactant was added only to the chlorsulfuron suspensions.

A granular formulation of tebuthiuron was also used in Experiment 5. These granules were applied uniformly by dividing each plot into ten sections of equal size and hand sprinkling pre-weighed packets of granules over each section.

Treatments in Experiments 1 and 2 were applied with no consideration of the stage of scouringrush growth, but in the other experiments, treatments were applied after numerous, small branches with strobili had been produced on the upper nodes of stems. This branching is a sign of biological activity which could be a positive influence on control by foliage-active herbicides such as chlorsulfuron.

In Experiment 1, a field drainage ditch near Napoleonville, Louisiana, was treated to determine the rates of bromacil and tebuthiuron required to control scouringrush. Five rates of each herbicide, ranging from 5.6 to 28 kg/ha, were applied in February, 1975.

In Experiment 2, the control of scouringrush by bromacil, hexazinone and tebuthiuron was compared when each was applied at 16.8 and 18 kg/ha. The first study was on a field drainage ditch near Thibodaux, Louisiana, with treatments applied in July, 1976; the second study was on a central ditch near Napoleonville, Louisiana, with treatments applied in February, 1977.

Experiment 3 involved two field studies conducted on central drainage ditches near Lockport, Louisiana. Soil-active treatments with tebuthiuron at 9.0 and 17.9 kg/ha and hexazinone at 11.2 kg/ha were compared with chlorsulfuron, a foliage-active herbicide, at 0.28 and 0.56 kg/ha. Treatments were applied in July, 1981, in the first study and in September, 1984, in the second study.

Experiment 4 involved one study on a central drainage ditch near Napoleonville, Louisiana, to determine rates of chlorsulfuron required to control scouringrush. Four rates ranging from 0.14 to 0.56 kg/ha were applied in May, 1982.

Experiment 5 involved one study on a central ditch in which tebuthiuron was applied either dry on a clay granule with 20% concentration or as the standard water-herbicide suspension. Treatments were initially applied in May, 1982, and reapplied

in June, 1983. Rates of granular tebuthiuron for the two dates were 9 + 9, 18 + 0 and 18 + 4.5 kg/ha.

RESULTS

The chemical and physical characteristics of soil, based on a composite sample of soil from 0 to 30 cm depth in each experiment, are shown in Table 1. The soils were relatively similar in organic matter content, ranging from 1.2 to 1.8%; in pH, ranging from 6.5 to 7.7; in cation exchange capacity, ranging from 12 to 18 meq/100 g; and in texture, ranging from silt loam to loam.

The initial study with bromacil and tebuthiuron on a field ditch on silt loam, Experiment 1, showed that control increased as the rate for both herbicides increased from 5.6 kg/ha, which gave almost no control, to 28 kg/ha (Table 2). Tebuthiuron gave effective control (90%) at 16.8 kg/ha whereas bromacil required 28 kg/ha for similar control.

Table 2. Control of scouringrush one year after treatment with several rates of bromacil and tebuthiuron when applied to a field drainage ditch on silt loam soil. (Experiment 1)

Herbicide and rate (kg/ha)	Control and (range of control)[1/] (%)
Bromacil - 5.6	5 (0 - 10)
Bromacil - 11.2	50 (40 - 60)
Bromacil - 16.8	60 (40 - 80)
Bromacil - 22.4	70 (60 - 80)
Bromacil - 28.0	80 (60 - 100)
Tebuthiuron - 5.6	10 (5 - 15)
Tebuthiuron - 11.2	50 (40 - 60)
Tebuthiuron - 16.8	90 (80 - 100)
Tebuthiuron - 22.4	90 (80 - 100)
Tebuthiuron - 28.0	100 -
None - 0.0	0 -

[1/] Among three replicates.

In Experiment 2, bromacil, hexazinone and tebuthiuron generally were more phytotoxic in the 1976 study on a field ditch than in the 1977 study on a central ditch (Table 3). At rates of 16.8 and 28 kg/ha, all herbicides gave perfect control in 1976, but in 1977, hexazinone and tebuthiuron each gave about 85% and 95% control, respectively, and bromacil only 46% and 78% control, respectively. Bromacil gave very good control of johnsongrass, which probably included both rhizomatous and seedling plants; tebuthiuron gave poor to fair control; and hexazinone gave poor control (Table 3).

Table 3. Comparative control, one year after treatment, of scouringrush on drainage ditches with three soil-active herbicides. (Experiment 2)

	Scouringrush control in two studies		
Herbicide and rate (kg/ha)	Field ditch on silt loam in 1976 (%)	Central ditch on loam in 1977 (%)	Johnsongrass control (Rating)
Bromacil - 16.8	100	46	Good to Excellent
Bromacil - 28.0	100	78	Excellent
Hexazinone - 11.2	95	79	Poor
Hexazinone - 16.8	100	85	Poor
Hexazinone - 28.0	100	97	Poor
Tebuthiuron - 16.8	100	88	Poor to Fair
Tebuthiuron - 28.0	100	95	Fair
None - 0.0	0	0	Poor

A comparison of the soil-active treatments with tebuthiuron or hexazinone and the foliage-active treatments with chlorsulfuron, Experiment 3, showed that tebuthiuron at 18 kg/ha was the most effective treatment, giving an average 94% control (Table 4). Foliage-active treatments with chlorsulfuron at 0.28 and 0.56 kg/ha gave an average 64% and 74% control, respectively, which was about equal to control with tebuthiuron at 9 kg/ha and hexazinone at 11.2 kg/ha (Table 4). Control with chlorsulfuron was quite variable between plots, particularly in 1984, ranging from 30% to 99%.

Table 4. Comparison of control, one year after treatment, by soil-active and foliage-active herbicide treatments applied to scouringrush on central drainage ditches on loam soil. (Experiment 3)

Herbicide and rate (kg/ha)	Control and (range of control)[1/] 1981 study (%)	1984 study (%)	Mean (%)
Soil active			
Tebuthiuron - 9.0	70 (65-75)	74 (50-99)	72
Tebuthiuron - 18.0	95 (92-98)	93 (80-100)	94
Hexazinone - 11.2	70 (65-75)	65 (50-90)	68
Foliage active			
Chlorsulfuron - 0.28	73 (60-85)	55 (30-99)	64
Chlorsulfuron - 0.56	83 (75-90)	64 (30-99)	74
None	0	0	0

[1/]Among three replicates.

In Experiment 4, control of scouringrush, at 1 and 2 yr following treatment with chlorsulfuron, increased as rate of chlorsulfuron increased from 0.14 to 0.42 kg/ha, with a rate of 0.56 kg/ha giving no additional control (Table 5). Control at 2 yr was less than at 1 yr, indicating that surviving scouringrush plants were initiating new growth. The treatments in this experiment caused an unusually rapid and complete desiccation of scouringrush stems as shown by the "apparent" control recorded 4 months after treatment (Table 5). This extensive desiccation apparently was caused by a combination of the chlorsulfuron treatments and an application of MSMA that was applied 1 month later to control johnsongrass.

Table 5. Effect of rate of chlorsulfuron on control of scouringrush on a central drainage ditch. (Experiment 4)

Herbicide and rate[1/] (kg/ha)	Apparent control 4 mo. after treatment (%)	Control 1 yr after treatment (%)	Control 2 yr after treatment (%)
Chlorsulfuron - 0.14	70	47	32
Chlorsulfuron - 0.28	95	64	55
Chlorsulfuron - 0.42	100	94	77
Chlorsulfuron - 0.56	100	92	68
None	0	0	0

[1/]Treatments were applied on 5-20-82 and a nonionic surfactant at 0.25% v/v was added to spray solutions. MSMA at 4.5 kg/ha was applied over treatments on 7-2-82 to control johnsongrass.

In Experiment 5, the initial treatments with tebuthiuron at 9 kg/ha applied as a water suspension and as a granule gave only 30% and 42% control, respectively, 1 yr after treatment, whereas tebuthiuron at 18 kg/ha applied as a granule gave 72% control (Table 6). Two applications of tebuthiuron at 9 kg/ha, applied 1 yr apart, gave 93% control as a granule and 73% control as a water suspension. Observations showed that water-suspensions of tebuthiuron caused partial or complete desiccation of many scouringrush stems within a few days following treatment whereas granular tebuthiuron did not have this effect.

Table 6. Comparison of rates and formulation of tebuthiuron for control of scouringrush on a central drainage ditch on silt loam soil. (Experiment 5)

Herbicide and rate[1/] (kg/ha)	Formulation[2/]	Control one yr after: 1st application (%)	Control one yr after: 2nd application (%)
Tebuthiuron - 9 + 9	Wettable powder	30	93
Tebuthiuron - 9 + 9	20% Granule	42	73
Tebuthiuron - 18 + 0	20% Granule	72	73
Tebuthiuron - 18 + 4.5	20% Granule	72	89

[1/] First application was made on 5-20-82 and second application was made on 6-8-83. MSMA at 4.5 kg/ha was applied over all treatments on 7-2-82 to control johnsongrass.

[2/] The wettable powder was suspended in water and applied as a spray; the granules were applied dry.

DISCUSSION

The herbicides bromacil, hexazinone and tebuthiuron are characterized as being relatively persistent in soil, moderately adsorbed on soil colloids, moderately mobile in soil, and absorbed by plant roots (1, 6, 7). In this series of studies, these soil-active herbicides generally gave good control of scouringrush, but relatively high rates were required for consistent control: about 17 kg/ha for tebuthiuron and hexazinone and about 28 kg/ha for bromacil. Control at lower rates was more variable. Several factors probably contributed to this variability, including number and depth of rhizomes, stage of scouringrush growth, soil texture and permeability of soil, adsorption characteristics of soil, and the type of ditches involved.

The variation in control that may be experienced with the same rates of soil-active herbicides on different ditches is shown in Experiment 2 (Table 3) in which control of a field ditch in 1976 generally was much better than control on a central ditch in 1977. Several factors may have been responsible for these differences. The field ditch had a broad bank that gently sloped to the bottom of the relatively shallow channel, whereas the central ditch had a bank that steeply sloped to a deep channel. Herbicides applied to a steep bank probably tend to be washed to the bottom of the channel rather than leaching into soil. The field-ditch soil may have been more permeable than the central-ditch soil because of the lower clay content (Table 1). Also, field ditches typically are cultivated and reditched after a few years whereas central ditches essentially remain undisturbed except for moving accumulated soil from the bottom of channels to the top of the banks. Thus scouringrush populations on field ditches may have a less dense stand and shallower rhizomes than populations on central ditches.

Another source of variation between the two ditches was the time of treatment, being July on the field ditch and February on the central ditch. An application of soil-active herbicides in February would seem to be advantageous because such early-season applications would have a good opportunity for movement by rain into the root zone of scouringrush where growth would be affected for a large part of the growing season. A July application, on the other hand, could offer some advantage because herbicides applied under high temperatures could cause some contact injury to stems. However, in a nonreported study, bromacil, hexazinone and tebuthiuron applied at 4.4 and 8.8 kg/ha in August, both with and without a surfactant, caused very little contact injury to scouringrush stems, although the results may have been affected by rain that occurred 24 hours after treatment. In the same study, MSMA at 4.4 kg/ha caused significant desiccation of stems.

Tebuthiuron at 18 kg/ha gave more effective control of scouringrush than chlorsulfuron at 0.56 kg/ha (Table 4), but chlorsulfuron gave very good control in one experiment (Table 5). Chlorsulfuron is characterized as being absorbed both by foliage and roots and is systemic (3). It has been reported to give near perfect control of scouringrush at rates as low as 0.04 kg/ha in spring in the the northern United States (2). Here, however, rates from 0.28 to 0.56 kg/ha were required for relatively consistent control on central drainage ditches. Control with chlorsulfuron was quite variable both within and between experiments with control ranging from 30% to 99% in the 1984 study of Experiment 3 (Table 4). Such variation probably reflects differences in stage of growth even along the same ditch. Newly-formed stems as opposed to older-stems probably absorb more chlorsulfuron, and other studies have shown that mowing, and the treating of new growth with chlorsulfuron increases control (7). However, mowing the steep slopes of central ditches would not be practical.

Johnsongrass was not controlled effectively by any of the herbicides except bromacil (Table 3), and a separate treatment with a herbicide such as MSMA would be needed for control when herbicides other than bromacil are used. Because MSMA injures scouringrush shoots, it probably should not be used prior to treatment with chlorsulfuron since absorption and translocation by the shoots may be adversely affected. However, an application of MSMA following a chlorsulfuron treatment may increase control as was surmised in Experiment 4.

Observations showed that bermudagrass [*Cynodon dactylon* (L.) Pers.] had invaded plots treated with tebuthiuron, hexazinone and chlorsulfuron about 1 yr after scouringrush was controlled but that about 2 yr were required where high rates of bromacil were applied. A bermudagrass ground cover is desirable to prevent the erosion of soil.

In most cases, even the best herbicide treatments did not achieve 100% control of scouringrush when rated 1 yr after treatment, and follow-up treatments would be needed to achieve eradication. Eradication of the weed on individual ditches is a desired goal because, as shown in Experiment 4 (Table 5) and from general observations, surviving plants can reinfest previously treated areas quite rapidly. Eradication on most farms is feasible because the number of ditchbanks infested with scouringrush is still quite low.

A control strategy for a farm should probably involve two phases: 1st, eradication of new infestations as they appear, to prevent the entire ditch from becoming infested; and 2nd, systematically eradicating scouringrush from individual ditches until all ditches on a farm are free of the weed.

Scouringrush rhizomes are very sensitive to desiccation by plowing. While herbicides will be needed for control on the more permanent central ditches, deep plowing before reforming the field ditches during the fallow year of the sugarcane crop cycle will greatly aid in control and should reduce the need for control with herbicides. Although the rhizomes sometimes grow into the first few rows of sugarcane adjacent to infested ditches, the standard practice of fallow plowing fields every fourth year and the routine cultivation of the crop probably prevent a more general invasion.

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VARIETAL SMUT RATINGS IN SUGARCANE BEFORE AND AFTER MID-SEASON RATOONING AND BETWEEN REPLICATED AND NONREPLICATED TESTS

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ABSTRACT

Commercial and candidate sugarcane (Saccharum interspecific hybrid) cultivars have been tested for resistance to smut (Ustilago scitaminea Sydow) since its identification in Louisiana in 1981. Seed cane of each cultivar was inoculated by dipping leaf-free stalks in a suspension of 5 X 10^6 teliospores per ml for 10 minutes and planting them immediately in the field. Ninety-two and 109 advanced candidates were planted in replicated tests on 30 August 1983 and 8 September 1984, respectively, while pre-CP assignments and newly assigned CPs were planted in nonreplicated tests later in the planting season (339 candidate cultivars on 26 September 1983 and 222 on 7 November 1984). In the spring and early summer following planting, stalks with whips were counted and cut out at ground level weekly. In July, after all stalks, healthy and diseased, had been counted, all cane was cut to ground level. Stalks with smut whips within the regrowth were counted and cut out weekly until November. Percentage of stalks with disease symptoms produced before and after the July cutting correlated significantly ($r>0.90$) in the late summer-planted, replicated tests in both years as well as in the fall-planted, nonreplicated material ($r=0.83$ for 1984 and $r=0.85$ for 1985). The level of smut whips per plot increased after the July cutting; however, the relationship among cultivars remained essentially the same although the ratings were revised. The data indicate that there is little advantage to ratooning of disease trials by July cutting in selecting for smut-resistant cultivars.

INTRODUCTION

When sugarcane smut, caused by Ustilago scitaminea Syd., was first observed in Louisiana in 1981 (5), smut-susceptible cultivars were planted on approximately 73% of the Louisiana sugarcane area (3). Although many cultivars used in Louisiana had been tested for smut resistance in other regions of the world, it was not necessary to plant resistant cultivars until the disease was actually found. However, since 1981 it has become necessary to test and select cultivars for smut resistance under Louisiana conditions. The objectives of this study were to examine test procedures and to determine if modifications of these procedures were necessitated by climatic conditions under which sugarcane is grown in Louisiana.

MATERIALS AND METHODS

Inoculated trials for estimating smut resistance of advanced candidate cultivars were planted annually in late summer at Houma, Louisiana. Seed cane of each commercial and candidate cultivar tested was inoculated by dipping leaf-free stalks in a suspension of approximately 5 X 10^6 teliospores per ml. The inoculum was prepared by adding 0.4 g of smut spores plus 0.53 ml of surfactant per liter of water. Seed cane was immersed for 10 minutes and planted immediately in the field. Teliospore viability was determined at the beginning of the procedure and at the end of the 4-5 hour dipping procedure. One milliliter of spore suspension was dispensed on the surface of solidified water agar and observed immediately for previous germination and then two hours later for continued germination. Spore viability ranged from 90 to 95% in these tests with less than 5% of the spores germinating during the dipping processes. The experimental design was a randomized, complete block with three replications. Planting was done on raised ridges 1.8 m apart. Cultivar plots were 4.6 m long and one row wide. The 1983-84 test was planted on 30 August 1983 and included four Louisiana commercial cultivars and 87 cultivars of the 1973-1982 series of CP assignments (selections from seed produced at the U. S. Sugarcane Field Station, Canal Point, Florida) and L assignments (selections from seed produced at the Louisiana Agricultural Experiment Station, Baton Rouge, Louisiana). The 1984-85 experiment was planted on 8 September 1984 and included four Louisiana commercial cultivars and 104 advanced candidate cultivars of the 1979-1983 series of CP and L assignments.

A second inoculated trial for pre-CP assignments and newly assigned CPs was planted annually in a nonreplicated test in the fall. The 1983-84 test was planted on 26 September 1983 and included four commercial and 335 candidate cultivars.

The 1984-85 test was planted on 7 November 1984 and included five commercial and 217 candidate cultivars. In both tests the commercial cultivars were replicated three times.

Each year fall growth was killed back by subfreezing temperatures during the winter months. Uninterrupted growth resumed in March of the next year which was designated as the test year.

Cultivars were grouped, based on percent smut infected shoots, into three disease reaction ratings--susceptible, intermediate, and resistant. The range of reactions used to define each rating was adjusted for each test using the reaction of the commercial cultivars as standards since the environment and other conditions associated with each test influenced the percent infection among the tested cultivars. The number of candidate cultivars were not equally distributed among the three groupings and the range assigned each group varied among the experiments. The commercial cultivars used in the tests were selected because of their known disease reaction to natural infection under commercial conditions.

Stalks with whips were counted beginning 17 May 1984 and 3 May 1985. To minimize spread of the pathogen in a still relatively smut-free area, whips were counted and cut out at ground level at weekly intervals. The whips counted and cut out were those borne terminally on shoots emerging from below ground; the axillary whips, which usually result from secondary infection of buds, whose incidence would be particularly sensitive to spore load, were not included in the data. On 5 July 1984 and 11 July 1985, all stalks, healthy and diseased, were counted. Diseased stalks included those with visible whips and grassy shoots (a symptom which most often precedes whip formation). All cane was then cut to ground level with a rotary, tractor-mounted cutter after the last count. Counts of stalks with whips in the ratoon crop were made from 12 September to 29 November 1984 and from 8 September to 23 November 1985. Total shoot counts were made on the last day of the final count. The accumulated total of diseased shoots were added to the final July and November counts as appropriate and the mean percentage of infected shoots was calculated for all cultivars.

RESULTS

The number of cultivars assigned to each smut disease reaction rating before and after the July cutting are compared within the two plantings of each year (Table 1). Percentage of stalks with disease symptoms produced before and after the July cutting correlated significantly (r=0.90 and r=0.94 for 1984 and 1985, respectively) in the late summer-planted, replicated tests (Table 2). In the fall-planted, nonreplicated tests correlations of percentages of diseased stalks produced before and after the July cutting were also correlated significantly in both years (r=0.83 for 1984 and r=0.85 for 1985) (Table 3). Average percentages of smut whips and grassy shoots per plot increased after the July cutting; however, few cultivars were classified differently between the two ratings (Tables 2 and 3). In the replicated late summer-planted tests, no variety differed by more than one classification category between the two ratings, and 80-84% of the cultivars did not differ in classification (Table 2). In the nonreplicated, fall-planted tests, the differences in pre- and post-midseason cutting ratings were somewhat greater. In each test only ten cultivars (3-4% of the total) differed by two ratings (Table 3).

Table 1. Number cultivars assigned to each smut disease reaction rating.

		1984			1985		
		No. of cultivars assigned to each rating category					
Planting	Counting period	Susceptible	Intermediate	Resistant	Susceptible	Intermediate	Resistant
Late summer	Before July cutting	33	19	40	34	24	51
	After July cutting	31	27	34	39	25	45
Fall	Before July cutting	51	66	222	95	23	104
	After July cutting	85	68	186	106	35	81

Table 2. Correlation coefficients and changes in disease reaction rating from before to after midseason cutting in the late-summer planted, replicated test.

Test year	Total no. cultivars	Correlation coefficient (r)	Rating change1/ (% of clones) -2	-1	0	+1	+2
1984	92	0.90*	0	12	80	8	0
1985	109	0.94*	0	13	84	3	0

1/ Increase in rating to greater resistance is +, to greater susceptibility -; ratings are susceptible, intermediate, and resistant. Thus, a change from intermediate to susceptible is a -1; a change from susceptible to resistant is a +2.

* Correlations are significant at P<0.001.

Table 3. Correlation coefficients and change in disease reaction rating from before to after midseason cutting in the fall planted, nonreplicated test.

Test year	Total no. cultivars	Correlation coefficient (r)	Rating change1/ (% of clones) -2	-1	0	+1	+2
1984	339	0.83*	2	21	74	3	<1
1985	222	0.85*	4	13	79	4	<1

1/ Increase in rating to greater resistance is +, to greater susceptibility -; ratings are susceptible, intermediate, and resistant. Thus, a change from intermediate to susceptible is a -1; a change from susceptible to resistant is a +2.

* Correlations are significant at P<0.001.

When the 1984 and 1985 results from before the July cutting were compared, the significance of the correlation coefficient depended on the test (Table 4). Percent disease shoots for the 45 cultivars that were repeated in the two replicated, late summer-planted test were highly correlated (r=0.90); whereas, the 40 cultivars which were in both nonreplicated tests in 1984 and in the replicated test in 1985 had a lower, but significant, correlation coefficient (r=0.52). The percent diseased shoots among the 62 cultivars tested both years in the nonreplicated, fall-planted test were not significantly correlated.

Table 4. Correlation coefficients and change in disease reaction rating1/ between 1984 test and 1985 test for repeated cultivars.

1984 test/ 1985 test	Total no. cultivars	Correlation coefficient (r)	Rating change2/ (% of clones) -2	-1	0	+1	+2
Late summer/ late summer	45	0.90*	0	17	70	13	0
Fall/ late summer	40	0.52*	15	35	50	0	0
Fall/fall	62	0.19 NS	19	19	45	15	2

1/ Based on ratings made before July cutting.

2/ Increase in rating to greater resistance is +, to greater susceptibility -; ratings are susceptible, intermediate, and resistant. Thus, a change from intermediate to susceptible is a -1; a change from susceptible to resistant is a +2.

* Correlations are significant at P<0.001.

The same pattern of results was obtained using percent diseased shoots for the comparisons among the ratoon crop after the midseason cutting (data not shown).

The disease reaction ratings changed least among the varieties repeated in the two late summer-planted, replicated tests and changed most among cultivars repeated in the two nonreplicated, fall tests (Table 4).

DISCUSSION

The general pattern of smut development reported from most sugarcane producing areas of the world is an increase in smut incidence in ratoon crops compared to the plant cane crop (1, 2). Whittle and Walker (6), however, found differing patterns of disease development among cultivars when planted cane infection was compared to ratoon infections in Guyana. In Louisiana, smut incidence has typically been highest in the plant cane crop, particularly in moderately susceptible cultivars (4).

In these tests, the July cutting was used to produce a ratoon crop within one growing season. This was done to conserve valuable field space and labor, to test as many cultivars as early as possible in the breeding program, and to test if smut development would increase in the ratoon crops. Our results indicated little change in disease reaction from the plant cane crop to the ratoon crop. Since sugarcane planted in Louisiana in late August or early September may grow 2-4 months before being killed to the ground by cold temperatures during the winter months, the Louisiana plant cane may have some of the characteristics of a ratoon crop.

The changes in smut rating of cultivars from the plant cane crop to the ratoon crop within the same growing season were more often from lesser to greater susceptibility (Tables 2 and 3). Whittle and Walker (6) postulated that premature 'ratooning' forces regrowth during a time when inoculum potential is at a maximum, thus influencing the level of smut found in the ratoon crop. The changes in smut susceptibility may also reflect the more typical smut development pattern as observed elsewhere without the influence of Louisiana winters. The data collected after July cutting, however, do not appear to improve our selection process as the number of cultivars that changed from one resistance category to another was relatively small.

The changes in classification of cultivars repeated in the 1984 and 1985 tests also tended to be from lesser to greater susceptibility. This suggests that escapes may have been initially classified as resistant. However, since cultivars are inoculated and tested at least five more times and are exposed to natural infection in outfield tests before release, it is unlikely susceptible cultivars will escape detection.

These data indicate that early season, replicated smut tests provide reliable evaluation of cultivars; mid-season cutting to produce ratoons altered few decisions to keep or discard a cultivar; and fall-planted, non-replicated smut tests do not provide consistent cultivar evaluation. Therefore, the practice of mid-season ratooning and the fall planting of a non-replicated test have been discontinued in Louisiana smut testing. The effect of ratooning mature sugarcane on the incidence of smut in the first ratoon crop among candidate cultivars is under investigation.

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FERTILIZATION OF SUGARCANE WITH HIGH PLANT POPULATION[1/]

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ABSTRACT

Field experiments were conducted with sugarcane to determine the fertilizer needs of high population cane on Commerce and Jeanerette silt loam soils. The cane was planted using a wide furrow method of planting, and rates of fertilizers were tested during two crop years in each experiment. Rates of nitrogen (N) and potash (K) were tested in five experiments on Commerce soil and rates of N, phosphate (P) and K were tested in one experiment on Jeanerette soil.

Significant average increases in yield were obtained from the application of N alone on Commerce soil with plant and first stubble cane, in the stalk weight with plant cane, and in stalk population in stubble cane. Significant increases were obtained in the yield of each crop from the application of K in combination with N on Commerce soil. Generally, there were increases in stalk population and weight due to the fertilizer treatments, but the average differences in these yield components among N and K rates were not significant. Significant increases in yield were obtained from the application of N alone and from P and K fertilizer combinations in first and second stubble cane on the Jeanerette soil.

INTRODUCTION

The fertilization of sugarcane grown with conventional methods of planting has been studied by several workers in Louisiana during the past years (1, 2, 3, 4, 6). These studies involved mainly rates and ratios, methods and time of application and sources of various fertilizers on the major soil types in the cane area.

In recent years, a wide furrow method of planting sugarcane has been developed by the authors (5) that can produce higher stalk population and cane yield than the conventional single drill method with a row spacing of six feet. The wide furrow method recommended to growers consists of planting cane in furrows 16-22 inches wide at the average rate of three to four continuous lines of stalks in each furrow on row spacing six feet wide. This new method of planting has the potential to increase the state average yield at least 20% from about 25 to over 30 tons per acre(5). The increase in yield is apparently due to less competition among plants within the drill and better utilization of sunlight, especially early in the growing season.

Information available on fertilization of high population cane with the wide furrow method is limited; therefore, this study was made to evaluate the fertilizer needs of cane planted by this method.

MATERIALS AND METHODS

Six field experiments to determine the fertilizer needs of high population cane were conducted on the St. Gabriel Research Station and sugarcane farms in the cane area. Each experiment was conducted during two crop years at locations, on soil types and with cane varieties shown in Table 1.

Experiment 1 was located on a Commerce silt loam soil on Allendale (AD) Plantation in Port Allen, Louisiana. It was conducted on plant cane and first stubble crops of the variety CP 70-330 in 1980 and 1981. Experiments 2, 3, 4 and 5 were located on Commerce silt loam soil on the St. Gabriel Research Station in St. Gabriel, Louisiana. They were conducted with plant and first stubble cane of the variety CP 65-357, except for variety CP 72-370 in Experiment 5 during a period from 1980 to 1985.

Experiment 6 was on a Jeanerette silt loam soil on M. A. Patout (MAP) Plantation in New Iberia, Louisiana. It was conducted with first and second stubble cane using variety CP 65-357 in 1981 and 1982.

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A soil analysis was made on a composite sample from each location according to soil testing methods used in Louisiana (Table 1). The soil cations were extracted with 1N ammonium acetate and measured by atomic absorption. Soil P was extracted with .03N ammonium fluoride in 0.1 N HCl and measured with an auto-analyzer. The pH of the soils was measured on a 1:1 water-soil ratio, and organic matter was measured by the Walkley-Black method (7).

Table 1. The year, location, soil type, cane variety and soil analysis for the six fertilizer experiments with sugarcane.

	Experiment number					
	1	2	3	4	5	6
Year	1980-81	1980-81	1981-82	1982-83	1984-85	1981-82
Location[1/]	AD	St. Gabriel				MAP
Soil type	Commerce silt loam					Jeanerette sil
Cane variety	CP 70-330	CP 65-357			CP 72-370	CP 65-357
Cane crop	Plant 1st stubble	Plant 1st stubble	Plant 1st stubble	Plant 1st stubble	Plant 1st stubble	1st stubble 2nd stubble
	Soil test analysis					
K, ppm	137	142	61	97	62	61
Ca, ppm	1758	1880	1577	2003	1566	1126
Mg, ppm	387	414	303	366	277	302
P, ppm	206	196	168	168	249	53
Organic matter, %	0.82	1.06	0.31	0.81	1.47	0.70
pH	7.30	6.50	7.90	7.00	6.80	5.90

1/ AD = Allendale Plantation; St. Gabriel, Research Station; MAP = M. A. Patout Plantation.

The fertilizer treatments tested in Experiments 1 through 5 were 120 and 240 pounds of N and 60, 120 and 180 pounds of potash with plant cane and 150 and 300 pounds of N and 90, 180 and 270 pounds of potash per acre with first stubble cane. The extractable soil P was relatively high in each test, and phosphate was not applied (Table 1). In Experiment 6 on Jeanerette soil, the treatments were 160 and 320 pounds of N, 40 and 80 pounds of phosphate and 140 and 280 pounds of potash per acre with first and second stubble cane. The extractable soil P and K were low at this location.

The plots in each experiment were three rows wide and ranged in length from 50 to 75 feet on the St. Gabriel Station and from 150 to 200 feet on farm locations. A randomized block design with three replications was used in each test. The cane was planted using the recommended wide furrow method of planting during September or October, and the fertilizer treatments were appplied in the off-bar furrows during the following April of each crop year.

The stalk population and average stalk weight were measured in each experiment on the Commerce soil at harvest time during November or December. The cane yields were measured by weighing the millable cane stalks on each plot using tractor-mounted scales. Sugar yields were derived from refractometer and polariscope readings of the cane juice in a 10-stalk sample. The data from each experiment were analyzed statistically using a standard analysis of variance procedure.

RESULTS AND DISCUSSION

Effects of the NK fertilizer treatments on cane and sugar yields in Experiments 1, 2, 3, 4 and 5 on Commerce soil are reported for plant cane in Table 2 and for first stubble cane in Table 3. The increases in yields due to the treatments were significant in three of the experiments with plant cane and in four of the experiments with first stubble cane. The largest increases occurred in Experiment 1 on Allendale Plantation in both the plant cane and first stubble cane crops. The soil organic matter was relatively low at each location (Table 1), and significant yield increases from N alone were obtained with plant and first stubble cane in two experiments. The extractable soil K was also low at most locations (Table 1), and the yield increases from potash application were significant in two experiments with plant cane and in one experiment with first stubble cane.

Table 2. Effects of fertilizers on the yield of plant cane on Commerce silt loam soil in Experiments 1, 2, 3, 4 and 5.

Fertilizer applied N-P_2O_5-K_2O	Cane and sugar yield of plant cane					
	AD	St. Gabriel				5-crop
	1-1981	2-1980	3-1981	4-1982	5-1984	ave.
lb/acre	Cane yield, tons/acre					
0-0-0	21.1	34.9	31.1	45.5	27.0	34.5
120-0-0	27.2	35.7	32.8	45.4	31.5	34.5
120-0-60	30.0	37.5	34.4	46.2	29.7	35.6
120-0-120	30.2	36.4	36.4	48.7	31.0	36.5
120-0-180	32.3	37.5	37.2	49.9	34.1	38.3
240-0-60	31.1	38.5	36.4	48.6	33.1	37.5
240-0-120	33.4	38.3	37.8	47.0	36.2	38.5
240-0-180	34.8	39.3	40.5	48.4	36.2	39.8
HSD .05	4.0	NS	4.4	NS	4.3	2.4
	Sugar yield, lb./acre					
0-0-0	3922	7130	6998	8407	5228	6337
120-0-0	5283	7931	6990	8395	5871	6894
120-0-60	5568	7825	7396	8612	5341	6948
120-0-120	5538	7453	7888	8731	5550	7032
120-0-180	6183	7762	7920	9191	5995	7410
240-0-60	5677	7877	7874	8979	6184	7318
240-0-120	6163	7960	8176	8723	6704	7545
240-0-180	6453	7800	8692	8986	7107	7808
HSD .05	741	NS	972	NS	1475	478

Table 3. Effects of fertilizers on the yield of first stubble cane on Commerce silt loam soil in Experiments 1, 2, 3, 4 and 5.

Fertilizer applied N-P_2O_5-K_2O	Cane and sugar yield of first stubble cane					
	AD	St. Gabriel				5-crop
	1-1981	2-1981	3-1982	4-1983	5-1985	ave.
lb./acre	Cane yield, tons/acre					
0-0-0	21.5	28.8	19.8	30.5	27.2	25.6
150-0-0	31.9	30.3	21.6	29.1	33.6	29.3
150-0-90	33.6	34.5	25.6	32.4	33.9	32.0
150-0-180	35.8	35.3	30.1	32.0	35.8	33.8
150-0-270	35.9	33.9	27.2	32.6	35.5	33.0
300-0-90	36.8	33.7	28.7	31.3	36.3	33.4
300-0-180	37.2	32.7	29.5	31.2	36.9	33.5
300-0-270	37.8	32.6	31.9	33.1	34.5	33.9
HSD .05	5.0	3.8	4.1	NS	5.8	2.2
	Sugar yield, lb./acre					
0-0-0	4362	5543	3797	5567	5267	4907
150-0-0	6685	5781	4357	5532	6525	5776
150-0-90	6984	6531	5109	5573	6564	6152
150-0-180	7274	6442	5944	5658	6626	6389
150-0-270	6848	6584	5303	5978	6832	6309
300-0-90	7457	6328	5803	5973	6857	6484
300-0-180	7421	6419	6002	5553	6389	6357
300-0-270	7018	6331	6406	5467	6396	6324
HSD .05	1002	730	1310	NS	1430	484

As an average of the five crop years on Commerce soil, the yield increases from N alone were significant with the plant cane and first stubble crops. The average increases in yield from 240 over the 120 pounds of N with plant cane and from 300 over the 150 pounds of N with first stubble were not significant at each potash rate. With plant cane, the average yield increases from 180 over the 0 and 60 pounds of potash were significant with the 120 N rate. The average increases

from 180 over the 60 pounds of potash approached significance with the 240 N rate. With first stubble cane, the average yield increase from 90 pounds of potash was significant with the 120 N rate, but higher rates of potash did not increase yield.

The effects of fertilizer treatments on stalk population and stalk weight in Experiments 1 through 5 are reported for plant cane in Table 4 and for first stubble cane in Table 5. Increases in stalk population due to the treatments were significant in three of the experiments in plant cane and in three of the experiments in first stubble cane. The increases in stalk weight were significant in four plant cane experiments and in only one first stubble experiment. As in cane yield, the largest increases in stalk population and weight occurred in Experiment 1 on Allendale Plantation.

Table 4. Effects of fertilizers on the yield components of plant cane on Commerce silt loam soil in Experiments 1, 2, 3, 4 and 5.

Fertilizer applied $N-P_2O_5-K_2O$	Stalk population and weight of plant cane: AD 1-1980	St. Gabriel 2-1980	St. Gabriel 3-1981	St. Gabriel 4-1982	St. Gabriel 5-1984	5-crop ave.
lb./acre	Stalk population, 1000/acre					
0-0-0	23.3	32.4	25.3	34.7	24.9	28.1
120-0-0	27.7	34.6	24.6	34.0	26.5	29.5
120-0-60	29.2	33.6	26.4	35.6	25.4	30.0
120-0-120	30.4	35.6	28.5	37.4	27.9	32.0
120-0-180	33.1	34.9	26.6	40.3	27.2	32.4
240-0-60	33.5	33.4	27.8	39.0	26.3	32.0
240-0-120	32.6	34.9	29.9	37.9	28.0	32.6
240-0-180	32.2	34.3	29.7	38.1	28.6	32.6
HSD .05	5.1	NS	3.6	5.2	NS	2.2
	Stalk weight, lb./stalk					
0-0-0	1.87	2.34	2.43	2.71	2.13	2.30
120-0-0	2.11	2.36	2.44	2.84	2.74	2.50
120-0-60	2.30	2.42	2.70	2.79	2.67	2.57
120-0-120	2.30	2.42	2.72	2.90	2.61	2.59
120-0-180	2.40	2.46	2.74	2.82	2.78	2.64
240-0-60	2.57	2.51	2.78	3.03	2.81	2.74
240-0-120	2.61	2.50	2.78	2.87	2.67	2.69
240-0-180	2.61	2.54	2.79	2.98	2.75	2.73
HSD .05	0.42	NS	0.30	0.35	0.50	0.19

Table 5. Effects of fertilizers on the yield components of first stubble cane on Commerce silt loam soil in Experiments 1, 2, 3, 4 and 5.

Fertilier applied $N-P_2O_5-K_2O$	Stalk population and weight of first stubble cane: AD 1-1981	St. Gabriel 2-1981	St. Gabriel 3-1982	St. Gabriel 4-1983	St. Gabriel 5-1984	5-crop ave.1/
lb./acre	Stalk population, 1000/acre					
0-0-0	20.9	24.0	30.3	25.4	23.9	24.9
150-0-0	25.3	25.5	33.3	28.9	29.3	28.5
150-0-90	24.4	25.2	32.1	28.4	29.8	28.0
150-0-180	28.6	26.4	35.7	29.2	30.6	30.1
150-0-270	29.8	25.6	35.4	28.5	29.9	29.8
300-0-90	28.1	24.8	35.2	28.3	31.4	29.6
300-0-180	29.0	25.2	34.6	28.5	30.3	29.5
300-0-270	29.1	25.0	32.1	28.9	28.2	28.7
HSD .05	4.2	NS	NS	2.5	6.5	2.1
	Stalk weight, lb./stalk					
0-0-0	1.67	-	1.89	1.84	2.06	1.86
150-0-0	2.27	-	1.90	1.82	2.33	2.08
150-0-90	2.27	-	2.15	2.07	2.31	2.20
150-0-180	2.56	-	2.20	2.03	2.47	2.31
150-0-270	2.51	-	2.04	2.04	2.48	2.27
300-0-90	2.50	-	2.02	2.05	2.59	2.29
300-0-180	2.67	-	2.04	2.00	2.59	2.33
300-0-270	2.64	-	2.19	2.00	2.63	2.37
HSD .05	0.43	-	NS	NS	NS	0.26

1/ Stalk weight averages for four-crop years.

As an average of the five crops on Commerce soil, significant increases in stalk weight were obtained from N alone with plant cane and in stalk population with stubble cane. The average differences in stalk population and in stalk weight between the N rates at each potash rate and among potash rates at each N rate were not statistically significant in either crop year. However, there was generally an increase in stalk population and weight with increasing fertilizer rates in each crop. Each N and potash combination treatment significantly increased the average stalk population and weight over the unfertilized check plot.

The effects of the NPK fertilizer treatments on cane and sugar yields of first and second stubble cane on Jeanerette silt loam soil in Experiment 6 are reported in Table 6. Increases in yield due to the treatments were significant in each crop year, with lower overall yield and larger increases in second than in first stubble cane. As an average of the two crops, increases in cane and sugar yields from 160 and 320 pounds of N were significant, but the differences between the two N rates with and without P and K applied were small. The organic matter and extractable P and K (Table 1) were low in the Jeanerette soil. The yield increases were significant from 160-40-140, 160-80-280, and 320-80-280 over N alone treatments. The increase from the higher over the lower rates of P and K approached significance at the 160 N rate and was significant at the 320 N rate.

Table 6. Effects of fertilizers on the yield of first and second stubble cane on Jeanerette silt loam soil at M. A. Patout Plantation in Experiment 6.

Fertilizer applied	Cane and sugar yield of stubble cane					
	1st stubble-1981		2nd stubble-1982		2-crop ave.	
$N-P_2O_5-K_2O$ Lb./A	Cane tons/A	Sugar lb./A	Cane tons/A	Sugar lb./A	Cane tons/A	Sugar lb./A
0-0-0	26.5	5687	13.1	2614	19.8	4151
160-0-0	28.4	6052	19.8	4147	24.1	5100
160-40-140	31.5	6772	21.6	4493	26.6	5633
160-80-280	33.3	7040	23.2	4910	28.3	5975
320-0-0	30.1	6460	19.7	4165	24.9	5313
320-40-140	31.3	6675	18.9	3894	25.1	5285
320-80-280	34.2	6987	23.4	4624	28.8	5806
HSD .05	3.3	703	3.0	702	2.1	447

In summary, the results indicated that fertilizer needs for high population sugarcane are 120 and 150 pounds per acre of N for plant and stubble cane, respectively, on Commerce soil and 160 pounds per acre of N for stubble cane on Jeanerette soil. Higher N rates did not increase yield. Commerce soil is low in extractable soil K and potash fertilizer is needed up to 180 pounds with plant cane and 90 pounds per acre with stubble cane. Higher potash rates increased stubble yields in one crop year. Jeanerette soil is low in soil P and K, and rates of at least 40 pounds of phosphate and 140 pounds of potash per acre are needed with a 160-pound N rate for stubble cane.

The current recommended rates per acre of 160 pounds of N for stubble cane on both soil types and 40 pounds of phosphate for stubble cane on Jeanerette soil are adequate for high population cane. However, high population cane needs more than the recommended 80-pound rate of N and potash for plant cane on Commerce soil and of potash for stubble cane on Jeanerette soil.

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THE ASSOCIATION OF SUGARCANE VARIETAL SUITABILITY TO MECHANICAL HARVESTING WITH THE DEGREE OF STALK BREAKAGE CAUSED BY THE MECHANICAL HARVESTER[1/][2/]

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ABSTRACT

The hypothesis that suitability of sugarcane varieties to harvesting by a soldier-type mechanical harvester is negatively associated with stalk breakage by the harvester was tested in 1983 and 1984. The percentages of stalks broken during harvesting were estimated for each of nine varieties at six locations. Although a significant genotype by location effect was found, varietal rank by mean percent stalk breakage over all locations followed the expected, based on previous harvesting experiences. A separate experiment was planted at the St. Gabriel Research Station to determine if plot length or year had an effect on the percentage of stalks broken during harvesting. Using five varieties, results from 5 m plots (infield length) were compared to results from 10 m plots (outfield length). Neither plot length nor year significantly affected the percentage of stalks broken during harvesting. The results of these experiments indicate that the suitability of a sugarcane variety to harvesting with a soldier-type mechanical harvester can be predicted from data of the percent stalks broken by a mechanical harvester relative to control varieties.

INTRODUCTION

The sugarcane harvesting system of Louisiana is completely mechanized. Therefore, the suitability of experimental sugarcane varieties to mechanical harvesting is of major concern to the Louisiana Sugarcane Variety Improvement Program.

The Louisiana sugarcane industry is unique in the use of soldier-type mechanical harvesters. For the most efficient operation, this type harvester requires non-brittle (8, 10) and erect (3, 8) varieties. However, sugarcane varieties differ in their degree of brittleness (4,7) and lodging (8, 12, 13). Accordingly, varieties that lodge under normal conditions are discarded early in the Louisiana Sugarcane Varietal Improvement Program (2).

Brittleness is more difficult to evaluate and therefore has not been determined as a regular part of this program. Fanguy (6) developed a device to estimate the brittleness of sugarcane. Cochran (4) later used a commercially available Instron Universal Testing Machine to measure brittleness and reported similar results. Fanguy (7) reported significant varietal differences for brittleness. He also found that, while ranking remained the same during the fall and winter, some varieties were more brittle during peak periods of growth than during the harvest season.

Fanguy (8) reported on the attempt to use ground loss estimates to determine suitability of sugarcane varieties to mechanical harvesting. Although a comprehensive method to evaluate varietal reaction to mechanical harvesting has not been reported, it has been observed that the stalks of poor harvesting varieties break easily during the harvesting process. It was therefore hypothesized that the suitability of a variety to mechanical harvesting is negatively associated with the percent of the stalks that are broken by a mechanical harvester.

The research reported herein had two basic objectives: The first objective was to determine if the suitability of sugarcane varieties to mechanical soldier-type harvesting was associated with the degree of stalk breakage caused by this harvesting system. The second objective was to determine if the degree of stalk breakage caused by the soldier-type harvester was affected by location, plot length or crop year.

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MATERIALS AND METHODS

Experiment I

The varietal and location effects on stalk breakage during harvesting were determined. Data were collected from the plant cane crop at six outfield variety test locations (5, 9) in 1983 (Table 1). The outfield test plots were three rows (5.54 m) x 10 m long, with a 1.23 m pathway between plots. Plots were planted in a randomized complete block design. The six commercial and three experimental varieties used in this study are listed in Table 2.

Table 1. A summary of the locations, harvest dates and the degrees of lodging for the outfield test locations in Experiment I, 1983.

Location	Parish	Date harvested	Degree of cane lodging
I.	W. Baton Rouge	11/21/83	very erect
II.	Assumption	11/22/83	erect
III.	St. Mary	11/29/83	moderately lodged
IV.	St. Mary	11/30/83	moderately lodged
V.	St. James	12/01/83	moderately lodged
VI.	Lafourche	12/05/83	heavily lodged

Table 2. Sugarcane varieties used in this study.

Variety	Status	Experiments used in
CP 65-357	Commercial	I, II
CP 70-321	Commercial	I, II
CP 72-355	Experimental	II
CP 72-356	Commercial	I, II
CP 72-370	Commercial	I
CP 73-351	Commercial	I
CP 74-383	Commercial	I
CP 76-301	Experimental	I
CP 76-331	Experimental[1/]	I
L 75-2	Experimental	I
NCo 310	Commercial	II

1/ Has been released for commercial production.

At harvest, cane in the test field at each location was rated for the overall degree of lodging. Cane on each row of the 3-row plots was cut with a soldier-type harvester and placed on a common heap row. Care was taken to keep the cane from each plot separate on the heap. Before the plots were weighed with a hydraulic grab system (9), two replicates were sampled for stalks broken during the harvesting process. Sampling consisted of randomly pulling 50 stalks from each plot. Stalks with pieces broken off or whole stalks that, when held horizontally, bent at damaged points were considered broken. The number of broken stalks for each sample was recorded.

An analysis of variance was used to determine the effects of varieties, locations, replications and variety by location interaction on percent broken stalks. Variance component estimates (1) were also used to generate an estimate of the degree of genetic determination.

To explore variety by location interaction, the data were expressed as percentile ranks (11) within locations.

To establish the industry's perception of the suitability of these varieties to mechanical harvesting, the personnel who conducted the variety trials and had considerable interaction with growers were asked to rank the commercial varieties used in this study from "perceived as most suited" to "perceived as least suited" to mechanical harvesting (5). Varietal rank with regard to percent broken stalks was compared to rank with regard to "perceived past harvesting performance" by regression analysis.

Experiment II

This study was conducted to determine if plot length, variety and year affect stalk breakage during mechanical harvesting.

Five varieties were planted in October 1982 in a randomized complete block design with a split plot arrangement. The plot length used in the infield testing stage (5 m) was compared to the plot length used in the outfield testing stage (10 m). A 1.85 m alley separated each plot. The varieties used are listed in Table 2. There were six replicates in this study.

The plant cane crop was harvested in December 1983. A single-row soldier-type harvester was used to harvest the test. A 50-stalk sample was pulled from each plot and the number of broken stalks was determined in the manner previously described. The first stubble crop was harvested in December 1984. The same procedures were followed as in the 1983 harvest.

An analysis of variance was conducted to determine the effects of replications, varieties, plot lengths, years and interactions.

RESULTS

Experiment I

The analysis of variance for percent stalks broken during harvesting in the outfield studies is summarized in Table 3. Differences among varieties, among locations and the variety x location interaction were significant at the 1.0% level of probability. There were no differences between replications at any location.

Table 3. Analysis of variance of percent broken stalks as a function of variety and location in Experiment I.

Source	df	MS	F value
Location	5	1342.0	29.29**
Rep (location)	6	14.8	0.99
Variety	8	330.9	10.50**
Location x variety	40	31.5	2.11**
Error	48	14.9	

**Significant at 1.0% level of probability.

In exploring the variety by location interaction, it should be noted that some varieties always did well while other varieties always performed poorly regardless of location (Table 4). For example, CP 65-357, a good harvesting variety, had the lowest percentage of broken stalks at four locations and second and third lowest percentage of broken stalks at the other locations. At all locations, CP 65-357 was not significantly different from varieties with the fewest broken stalks. At the other extreme, L 75-2 and CP 76-301 were not significantly different from the varieties with the highest percent broken stalks. L 75-2, an experimental variety that was not released as a commercial variety because of poor harvestability, had the highest percent broken stalks at two locations and the second highest percent at the remaining locations.

The percent broken stalks of the two commercial varieties that were considered worst harvesting (CP 70-321 and CP 72-356) were most affected by location. At the two locations where the cane was erect, CP 70-321 had few broken stalks. However, at the locations where the cane was lodged, this variety had a significantly higher relative number of broken stalks.

Table 4. Percentile ranks of varieties by location for the number of whole stalks on the heap row after mechanical cutting in Experiment I.[1/]

Variety	Location I	II	III	IV	V	VI	Mean
CP 65-357	90.0	86.5	79.5	78.5	86.0	81.0	70.3
CP 70-321	53.5	54.5	23.5	14.0	10.0	15.5	37.4
CP 72-356	25.5	32.0	62.5	35.0	40.5	52.5	44.1
CP 72-370	64.0	46.5	53.5	78.5	53.5	66.5	57.8
CP 73-351	79.5	65.0	69.0	86.0	86.0	68.0	67.7
CP 74-383	52.0	79.5	39.0	55.0	65.5	53.5	51.8
CP 76-301	14.0	17.0	28.5	31.0	47.0	44.0	36.4
CP 76-331	49.5	54.5	75.5	54.5	41.5	41.5	50.5
L 75-2	16.5	9.0	14.0	12.5	15.5	23.5	28.9

1/ The cane was erect at locations I and II, moderately lodged at locations III, IV and V and severely lodged at location VI.

It should be kept in perspective that, although there was a significant variety x location interaction, the vast majority of the phenotypic variance was due to genotype. Relative constant varietal rank across locations resulted in the degree of genetic determination to be estimated at 90% in this experiment.

The rank of varieties with regards to mean percent stalks broken across all locations was compared to the rank of varieties with regards to perceived suitability to mechanical harvesting. This comparison is summarized in Table 5. The varieties CP 76-301 and CP 76-331 were not included in the comparison because agronomists did not have enough experience with these varieties in mechanically harvested trials to rank them for suitability to mechanical harvesting. The significant rank correlation indicates that the percent stalks damaged by the mechanical harvester is highly and inversely associated with the industry's perception of how suited a variety is to mechanical harvesting.

Table 5. Comparison of varietal rank with regards to perceived suitability to mechanical harvesting to ranking with regards to percent broken stalks - Experiment I.

	Perceived suitability rank[1/]	Broken stalk rank
CP 65-357	1	1
CP 70-321	5	6
CP 72-356	6	5
CP 72-370	2	3
CP 73-351	4	2
CP 74-383	3	4
L 75-2	7	7
	Rank correlation (r) = .86*	

1/ Low number indicates most suitable to mechanical harvesting.

The results of Experiment I suggest that varietal suitability to mechanical harvesting may be estimated by determining the percent stalk breakage during the harvesting process. This method could be used especially to identify varieties which would be considered either extremely suited or extremely non-suited to mechanical harvesting in Louisiana.

Early knowledge of varietal suitability to mechanical harvesting would be extremely beneficial and particularly useful in the crossing program. Such knowledge, along with an estimate of narrow sense heritability, would help prevent inadvertent proliferation of crosses with high frequencies of poor harvesting progenies. Likewise, varieties with a high level of broken stalks at harvest could be eliminated early in the selection and testing stages.

Experiment II

Three of the commercial varieties used in this study (CP 65-357, CP 70-321 and CP 72-356) were also in Experiment I. The commercial variety NCo 310 was included because it was known to be a good harvesting variety. The variety CP 72-355 was included because it was an experimental variety that was not released due to harvesting problems. Two years of data were accumulated to determine if there were differences attributable to year effects.

The results of the analysis of variance are presented in Table 6. There were significant differences among varieties (P>0.05). There was also a significant year x variety interaction.

Table 6. Combined analysis of variance of percent broken stalks in Experiment II.

Source	df	MS	F value
Year	1	21.0	0.79
Rep (year)	10	26.7	1.13
Variety	4	483.6**	20.50**
Year x variety	4	88.0*	3.73*
Rep x variety (year)	40	23.6**	4.37**
Plot	1	0.0	0.00
Plot x variety	4	7.3	1.34
Year x plot	1	15.0	2.87
Year x plot x variety	4	9.4	1.74
Rep x plot x variety (year)	50	5.4	

* Significant at 5.0% level of probability.
** Significant at 1.0% level of probability.

In Table 7, the ranking of varieties with regards to the percent stalk breakage is compared to the ranking of varieties with regards to perceived suitability to mechanical harvesting. The two varieties considered to be the most suited to mechanical harvesting (NCo 310 and CP 65-357) actually had the fewest broken stalks. As expected, CP 72-355 had the highest percent of broken stalks. The degree of genetic determination was estimated to be 81% in this experiment.

Table 7. Ranking of varieties used in Experiment II1/ with regards to perceived suitability to mechanical harvesting.

Variety	Perceived suitability rank2/	Broken stalk rank
NCo 310	1	2
CP 65-357	2	1
CP 70-321	3	4
CP 72-356	4	3
CP 72-355	5	5
	Rank correlation (r) = 0.8	

1/ From survey of professional agronomists in outfield and infield stages of variety testing.

2/ Low number indicates most suited to mechanical harvesting.

There were no significant differences in stalk breakage due to plot length or to crop year. Because of this, it would seem probable that reliable estimates of varietal suitability to mechanical harvesting could be made as early as the infield stage of the program.

DISCUSSION

The hypothesis that suitability of sugarcane varieties to mechanical harvesting is negatively associated to the percent stalks broken by a soldier-type mechanical harvester was tested in two separate experiments.

In Experiment I, the stalk breakage of nine sugarcane varieties subjected to soldier-type mechanical harvesting was determined at six locations. There were significant differences among varieties. Good harvesting varieties had relatively lower percentages of broken stalks while poor harvesting varieties had higher percentages of broken stalks at most locations. The commercial variety CP 70-321 is considered to be poorly suited to mechanical harvesting. This variety had the highest percent broken stalks at three of the six locations. CP 70-321 performed relatively well at the two locations where the cane in the test field was erect. For this variety, the apparent increase in relative stalk breakage caused by lodging is in agreement with the relative increase in ground loss caused by lodging as reported by Fanguy (8). In general, the results of this stalk breakage method closely match the industry's perception of the suitability of varieties to mechanical harvesting.

Experiment II was conducted to determine if plot length or crop year had an effect on the percent of stalks broken by a mechnical harvester. Again, there were differences among varieties. More importantly, there were no significant differences between the two plot lengths used. This suggests that accurate estimates of the relative suitability of a variety to mechanical harvesting can be made with relatively short plots.

The G x E reported in Experiment I suggest that data from several locations and/or years should be gathered before the relative harvestability of experimental varieties can be accurately assessed. Regular availability of information regarding varietal suitability to mechanical harvesting would be useful in determining if varieties should be advanced to further stages of testing. The most important use of the data, however, may be in the crossing program. The data presented herein indicates that harvestability as a heritable trait has a high degree of genetic determination (90% and 81% in Experiments I and II, respectively). Therefore, it should be considered at the time of crossing.

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PRODUCTION GOALS

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ABSTRACT

A description of a method used to improve communication and increase personal contact of the management and supervisory employees is discussed. This is accomplished by establishing difficult but achievable goals for all important parameters of production. The format is set up on a weekly basis and actual results are compared to the preset goals. Meetings are held immediately after the actual run figures are available, and these comparative figures are reviewed by management and operations staff. During this review, plans are developed and discussed to correct problems and improve results.

INTRODUCTION

This presentation is to share a method of setting goals and comparing actual results of sugarcane processing operations. This method has been in use for four years. It is hoped that from the information presented, those of you who want such a system can develop one best suited to your needs and to your operation. This system was initiated to improve lines of communication, establish guidelines to evaluate performance, and monitor sugar factory operations with the ultimate aim of improving efficiency and recovery.

MATERIALS AND METHODS

A production plan booklet was developed containing tables of relative parameters and control data broken down into several major categories. The number of weeks or runs or periods which would be used was determined by estimating the size of the crop and selecting an ultimate crop period and a weekly target of tons of cane ground. With this information, the data for each run could be calculated. The data necessary to obtain the above objectives are used to establish the number of vertical lines of information needed on all of the tables. The general categories to be used were then selected. Six major categories were chosen: General with two tables; Milling with three tables; Time Account with one table; Gas Consumption with one table; Boiling House with two tables; and Sugar Balance with one table. Data parameters to be reviewed in each major category were selected, always keeping in mind the influence of each data target on overall results. Goals were set for each parameter of each run. These goals were set high but within reach. Past records, experience, expertise, and discussions with the technical staff were used to set and agree to these goals. It was felt that all goals must be difficult to attain and must reflect our highest ambitions. After the goals were established, the tables were reviewed by top management. The tables contained two columns for each parameter--goal or target in one column and actual in the other column. The goals were typed in and the tables were printed and set up into booklets. Most of the targets were recorded for the run and to-date in order to observe the crop progress at any time. Each person on the management team received a booklet. A pre-crop meeting of this group was held and all goals were reviewed and finalized.

During operations, production plan meetings were held at a shift change normally at 4:00 p.m. This allowed supervisors from two shifts (8 to 4 and 4 to 12) to attend these meetings. Top management was present at all these meetings. The meetings were held the day each run ended so that it would be as close to available results as possible. The actual data sheets were compiled by the vice president. At the beginning of the meeting, the actual results achieved by the factory were read to those present who had to personally record these results in his own booklet. This was done because it was felt that one could better remember the results if one wrote them down. The results were then reviewed comparing actual to goals.

RESULTS

It was found that, in addition to opening lines of communication and creating initiative and incentive to improve our individual and group performance, these meetings were educational and interestingly informative. This allowed engineers to appreciate the problems of fabrication personnel and vise versa. Top management

became closer to supervision and were afforded a weekly opportunity to grade or evaluate the general performance. It also afforded an opportunity for top management to discuss important issues concerning operating personnel and procedures. All were able to exchange views and develop a game plan to improve those areas which were below target and maintain those which were on target. It also became evident that station operators were looking forward to the daily manufacturing reports so that they could see how they were doing with the goals over which they had some control.

It must again be pointed out that this method of evaluating performance resulted in information that reached personnel from all areas of the factory. This new line of communication allowed each to be concerned about the other and they then were better able to take action or offer recommendations that helped the entire operation.

DISCUSSION

Table 1 compares tons cane ground for run and to-date and pounds of 96 sugar per gross ton of cane for run and to-date. Because of stoppage eight to ten hours every two weeks for wash outs, some of the data reflects this and is targeted for this. The yield per ton of cane is normally targeted by the last 5-year average which is steadily rising in the years under review.

Table 1. General.

Run	Tons cane ground					Lbs. 96° sugar/gross ton cane			
	Run		To date			Run		To date	
no.	Target	Actual	Target	Actual		Target	Actual	Target	Actual
1	45,495	29,561	45,495	29,561		165	166	165	166
2	49,140	44,623	94,635	74,184		175	177	170	173
3	52,800	--	--	--		--	--	--	--
4	49,920	55,005	197,355	129,189		190	170	178	171
5	52,800	44,470	250,155	173,659		195	180	182	174
6	49,140	50,430	299,295	224,089		200	196	184	179
7	51,975	52,237	351,270	276,326		205	190	188	181
8	49,140	50,917	400,410	327,243		205	201	190	184
9	51,150	49,048	451,560	376,291		205	193	191	185
10	46,500	51,564	498,060	427,855		200	192	192	186
11	36,170	15,339	534,230	443,194		192	200	192	187
Total	534,230	443,194	534,230	443,194	Avg.	192	187	183	187

Table 2 shows total sugar production and cane payment information as determined by the core laboratory and with actual sugar production. This monitor on sugar purchased in the cane and actual sugar made is most important (liquidation factor).

Table 3, the first of three milling tables, shows tons cane ground per hour; tons cane ground per day; and sucrose extraction. These targets were also influenced by cane fiber content and lower quantity of cane ground at wash outs.

Table 4 sets targets for imbibition percent cane; and depicts fiber percent cane; bagasse pol; bagasse moisture; and last roll brix.

Table 5 shows reduced extraction; purity drop; milling loss--sucrose over fiber in bagasse; and fiber rate. Both Tables 4 and 5 represent milling data and most of the factors that influence these.

Table 6 shows an accounting of time for comparisons of time grinding-hours; time lost-hours; time efficiency percent; and clean up days.

Table 7 shows what can be the costliest item of material to operate our factory. It presents a comparison between gas consumption in M.C.F. and in M.C.F. per ton gross cane.

Table 2. General.

Run No.	Lbs. 96° sugar made & estimated: Run Target	Run Actual	To date Target	To date Actual		CRS/gross ton cane[1/]: Purchase	M&E	Liquidation F Est.	Liquidation F Actual
1	7,500,000	4,825,300	7,500,000	4,825,300		151	166	87	95.63
2	8,600,000	7,920,200	16,100,000	12,745,500		159	177	87	97.39
3	9,768,000	--	25,868,000	--		--	--	--	--
4	9,485,000	9,329,300	35,353,000	22,074,800		152	170	87	97.00
5	10,296,000	8,078,700	45,649,000	30,153,500		162	180	87	96.61
6	9,828,000	9,907,275	55,477,000	40,060,775		166	196	87	96.26
7	10,655,000	10,058,305	66,132,000	50,119,080		165	190	87	100.17
8	10,074,000	10,222,650	76,206,000	60,341,730		181	201	87	96.24
9	10,486,000	9,486,727	86,692,000	69,828,457		170	193	87	98.89
10	9,300,000	9,643,020	95,992,000	79,471,477		188	192	87	94.264
11	6,875,000	3,018,360	102,867,000	82,489,837		176	200	87	98.530
Total	102,867,000	82,489,837	102,867,000	82,489,837	Avg.	167	187	87	97.010

1/ Lbs. commercially recoverable sugar per gross ton cane.

Table 3. Milling.

Run no.	Tons cane/hour Target	Tons cane/hour Actual	Tons cane ground/day: Run Target	Run Actual	To date Target	To date Actual	Sucrose extraction: Run Target	Run Actual	To date Target	To date Actual
1	295	255	6,499	4,373	6,499	4,373	89.0	88.3	89.0	88.3
2	305	315	7,020	6,375	6,713	5,391	90.0	89.9	89.5	89.3
3	315	--	7,543	--	7,021	--	91.0	--	90.0	--
4	320	305	7,131	3,929	7,048	4,654	92.0	89.9	90.5	89.6
5	320	296	7,543	6,396	7,148	5,004	92.0	89.4	90.8	89.5
6	320	327	7,020	7,204	7,126	5,373	92.0	90.0	91.0	89.6
7	315	330	7,425	7,462	7,168	5,673	92.0	90.6	91.1	89.8
8	315	330	7,020	7,274	7,150	5,874	92.0	90.2	91.2	89.9
9	315	344	7,307	7,007	7,168	6,000	92.0	89.4	91.3	89.8
10	310	330	6,643	7,366	7,115	6,138	92.0	88.3	91.4	89.6
11	300	318	7,234	6,906	7,123	6,162	92.0	89.9	91.5	89.6
Avg.	312	316	7,126	6,429	7,025	5,464	91.5	89.6	91.5	89.6

Table 4. Milling.

Run no.	Imbibition % cane Target	Imbibition % cane Actual	Fiber % cane Target	Fiber % cane Actual	Bagasse pol Target	Bagasse pol Actual	Bagasse moisture Target	Bagasse moisture Actual	Last roll brix Target	Last roll brix Actual
1	20.0	22.4	13.0	15.0	2.90	3.51	52.0	52.2	4.0	3.5
2	20.0	17.3	13.5	13.1	2.95	3.53	51.0	53.1	4.3	4.8
3	20.0	--	14.0	--	3.00	--	51.0	--	4.5	--
4	20.0	22.7	14.0	14.4	3.05	3.20	51.0	52.7	4.5	4.2
5	20.0	23.0	14.5	14.1	3.05	3.43	51.0	54.3	5.0	4.9
6	20.0	21.4	14.5	13.8	3.05	3.64	51.0	52.7	5.0	4.5
7	20.0	22.6	14.5	13.7	3.00	3.39	51.0	51.9	5.0	4.3
8	20.0	20.8	14.0	15.4	3.00	3.40	51.0	50.7	5.0	4.9
9	20.0	20.6	14.0	15.3	3.00	3.57	51.0	50.4	5.0	4.7
10	20.0	18.4	14.0	15.5	3.00	3.76	51.0	52.0	5.0	6.1
11	20.0	16.6	14.0	14.8	3.00	3.50	51.0	52.0	5.0	6.9
Avg.	20.0	20.6	14.0	14.5	3.00	3.50	51.0	52.2	4.7	4.8

Table 5. Milling.

Run no.	Reduced extraction: Run Target	Reduced extraction: Run Actual	Reduced extraction: To date Target	Reduced extraction: To date Actual	Purity drop: FEJ - dilute[1/]	Purity drop: FEJ - L.E.J.[2/]	Milling loss S/F in B.[3/]	Fiber rate[4/]
1	90.0	90.5	90.0	90.5	0.54	4.02	8.12	.032
2	91.0	90.4	90.5	90.5	1.26	6.85	8.36	.034
3	92.0	--	91.3	--	--	--	--	--
4	93.3	91.5	91.8	90.9	1.22	7.05	7.41	.036
5	93.3	90.7	92.0	90.9	1.77	8.63	8.33	.034
6	93.3	91.0	92.3	90.9	2.01	8.43	8.55	.037
7	93.0	91.5	92.5	91.0	1.88	7.23	7.24	.037
8	93.0	92.3	92.7	91.2	1.76	8.41	7.56	.042
9	93.0	91.6	92.7	91.3	1.88	7.66	7.90	.043
10	93.0	90.9	92.8	91.2	1.43	7.14	8.67	.042
11	93.0	91.7	92.9	91.3	1.91	8.44	8.03	.039
Avg.	92.5	91.2	92.0	91.0	1.57	7.39	8.02	.038

1/ Purity of first expressed juice - purity of dilute juice.
2/ Purity of first expressed juice - purity of last expressed juice.
3/ Ratio of sucrose to fiber in bagasse.
4/ Tons fiber per hour per square foot of roll.

Table 6. Time account.

Run no.	Gross time hours	Time grinding hours: Target	Time grinding hours: Actual	Time lost hours: Target	Time lost hours: Actual	Time efficiency percent: Target	Time efficiency percent: Actual	Crop days	Clean up days: Target	Clean up days: Actual
1	166	155	116	11	47	94	71	7		
2	168	156	142	12	26	93	85	7	1	
3	168	165	--	3	--	98	--	7	--	
4	168	156	181	12	155	93	46	7	1	
5	168	165	151	3	17	98	90	7		
6	168	156	154	12	14	93	92	7	1	
7	168	165	159	3	9	98	94	7		
8	168	156	154	12	14	93	92	7	1	
9	168	165	143	3	25	98	85	7		
10	168	155	156	13	12	92	92.9	7	1	
11	122	116	49	6	5	95	91	5		
Total	1,800	1,710	1,405	90	324	95	84	75	5	

Table 7. Gas consumption.

Run no.	M.C.F.: Run Target	M.C.F.: Run Actual	M.C.F.: To date Target	M.C.F.: To date Actual		M.C.F./ton gross cane: Run Target	M.C.F./ton gross cane: Run Actual	M.C.F./ton gross cane: To date Target	M.C.F./ton gross cane: To date Actual
1	10,148	16,415	10,148	16,415		0.22	0.56	0.22	0.56
2	4,850	4,024	14,998	20,439		0.10	0.09	0.16	0.28
3	3,440	--	18,438	--		0.07	--	0.11	--
4	2,640	14,038	21,078	34,477		0.05	0.26	0.09	0.27
5	2,496	2,658	23,574	37,135		0.05	0.06	0.09	0.21
6	2,640	6,645	26,214	43,780		0.05	0.13	0.08	0.20
7	2,457	6,252	28,671	50,032		0.05	0.12	0.08	0.18
8	2,600	3,881	31,271	53,913		0.05	0.08	0.07	0.17
9	2,457	9,971	33,728	63,884		0.05	0.20	0.07	0.17
10	3,069	15,866	36,797	79,750		0.06	0.31	0.07	0.19
11	6,450	3,993	43,247	83,743		0.18	0.26	0.08	0.19
Total	43,247	83,743	43,247	83,743	Avg.	0.08	0.21	0.10	0.24

Table 8 shows a comparison among boiling house efficiency; sugar pol; sugar safety factor; and molasses purity.

Table 8. Boiling house.

Run No.	Boiling house efficiency: Run Target	Run Actual	To date Target	To date Actual	Sugar pol Target	Sugar pol Actual	Sugar Safety factor Target	Sugar Safety factor Actual	Molasses purity Target	Molasses purity Actual
1	96.5	95.1	96.5	95.1	98.8	97.4	0.25	0.17	32.0	38.8
2	97.5	96.6	97.0	96.0	98.8	98.0	0.25	0.27	31.0	35.9
3	97.5	--	97.2	--	98.8	--	0.25	--	33.0	--
4	98.0	93.0	97.4	94.7	98.8	98.2	0.25	0.27	33.0	36.2
5	98.5	96.7	96.6	95.2	98.8	97.7	0.25	0.21	34.0	32.8
6	98.5	96.8	97.8	95.6	98.8	97.7	0.25	0.18	34.0	38.6
7	98.5	97.2	97.9	95.9	98.8	97.6	0.25	0.18	34.0	35.8
8	98.5	96.2	98.1	96.0	98.8	98.3	0.25	0.24	34.0	39.7
9	98.5	97.2	98.2	96.1	98.8	98.0	0.25	0.27	35.0	36.9
10	98.0	97.0	98.1	96.2	98.8	98.4	0.25	0.27	35.0	38.5
11	97.5	96.5	98.0	96.3	98.8	98.7	0.25	0.26	35.0	38.8
Avg.	98.0	96.2	97.5	95.7	98.8	98.0	0.25	0.23	33.6	37.2

Table 9 again looks at the boiling house and shows comparisons among syrup brix; mud pol; undetermined losses percent cane; pounds mud per ton gross cane; and gives purity rise and purity drop information. Both Tables 8 and 9 represent boiling house data that have major influence on recovery.

Table 9. Boiling house.

Run No.	Syrup Brix T	Syrup Brix A	Mud pol T	Mud pol A	Undt. losses % C T	Undt. losses % C A	Lbs. mud/T.G.C. T	Lbs. mud/T.G.C. A	Purity rise: Dilute time to evap. supply	Purity rise: Evap. supply to syrup	Purity drop: "C" Mass/ molasses Run	Purity drop: "C" Mass/ molasses To date
1	59.0	56.6	3.5	5.0	0.25	0.15	60	76	0.92	-0.55	26.25	26.25
2	60.5	51.8	3.5	3.6	0.10	0.12	70	72	3.98	-1.71	24.06	24.06
3	59.0	--	3.5	--	0.05	--	70	--	--	--	--	--
4	60.5	57.3	3.3	3.3	0.05	0.34	75	103	0.42	1.15	24.07	24.06
5	59.0	56.3	3.3	5.4	0.05	0.07	75	98	1.04	1.40	25.08	24.28
6	60.0	57.9	3.3	4.0	0.05	-0.07	70	79	0.60	1.17	22.28	24.12
7	59.0	56.9	3.7	4.2	0.03	-0.04	70	90	0.35	0.47	22.27	24.01
8	60.0	56.4	3.7	4.0	0.03	-0.01	70	90	0.35	0.47	22.77	24.01
9	59.0	59.3	3.7	4.7	0.03	-0.09	70	88	0.68	-0.34	23.12	23.95
10	60.0	57.9	3.5	5.0	0.03	0.12	70	86	-0.28	-0.98	22.93	21.90
11	59.0	51.7	3.5	4.4	0.03	0.47	70	97	1.01	-0.14	22.77	21.93
Avg.	59.5	56.2	3.5	4.4	0.06	0.11	70	88	0.91	0.09	23.56	23.88

T = Target; A = Actual

Data in Table 10, which is very unique, compares target and actual figures of the sugar balance using cane as the pounds of sugar available in each ton of cane and then comparing the pounds of sugar that end in bagasse; juice; molasses; mud; undetermined; and in sugar. This table shows the quantity of sugar that came in with the cane and where it was accounted for in products, by-products, and losses.

Table 10. Sugar balance.

Run no.	Cane		Bagasse		Juice		Molasses		Mud		Undt.		Sugar	
	T	A	T	A	T	A	T	A	T	A	T	A	T	A
1	183	217	17	25	166	192	17	19	2	4	2	3	145	166
2	206	226	18	23	188	203	19	20	3	3	1	3	165	177
3	218	--	19	--	199	--	20	--	3	-	1	-	175	--
4	228	220	19	22	209	198	20	19	3	4	1	5	185	170
5	232	230	20	24	212	206	19	18	3	6	1	2	190	180
6	237	245	20	24	217	221	19	21	2	3	1	1	195	196
7	240	234	20	22	220	212	15	18	4	4	1	0	200	190
8	247	246	20	23	227	223	17	18	4	4	1	0	205	201
9	247	238	20	25	227	213	17	17	4	3	1	0	205	193
10	247	239	20	26	227	213	18	17	3	4	1	0	205	192
11	240	246	20	24	220	222	16	18	3	4	1	0	200	200
Avg.	230	234	19	24	210	210	18	19	3	4	1	1	188	187

T = Target; A = Actual

A brief review of our production plan for the 1985 crop is as follows: In Table 1, the tons cane ground target was reached at the fourth run and held thereafter. The target was not reached for any of the other parameters on this table. It can also be seen that Hurricane Juan caused the factory to shut down for the third run.

In Table 2, sugar production goals were not reached due to maturity during runs one and two and then due to hurricane damage thereafter.

In Table 3, the goal of tons cane per hour was achieved, but fell short of most of the other goals in this table. Some were affected by Hurricane Juan and practically all were affected by excessive lost time.

Table 4 shows that the imbibition goals and last roll brix goals were reached, but not bagasse pol and bagasse moisture. There were many discussions at weekly meetings on how to improve bagasse pol and bagasse moisture. Frequent brix curves were run on the mills to determine where to apply efforts to correct the below target results.

Table 5 again indicated that mill performance was below target.

In Table 6, we were far below our target. This is an area in which performance has been bad for many years, and extra efforts are being made to improve this. Top management has placed much emphasis on this problem and the goal is to get within reasonable limits.

In Table 7, failures of this crop were mainly due to electrical and mechanical problems. Poor quality bagasse after the hurricane had a small effect on bagasse burning capabilities.

Table 8 shows boiling house targets were not met. In spite of this, sugar recovery per ton of cane was very good. Targets set here were very difficult to achieve.

In Table 9, very difficult targets were set and were not met. There is a shortage of evaporator capacity when using high imbibition and grinding at high rates. Mud losses are excessive and difficult to improve with existing equipment. Purity rises from dilute juice to syrup were erratic and below normal. Purity drop from "C" massecuite to final molasses was less than wanted.

Table 10 shows how much sugar is in each ton of cane in the first column and then proceeds to show where it ends up. As can be seen, many pounds go to bagasse and molasses and anything that can be done to reduce this and other losses is worthwhile.

It can be seen from 1985 tables that efforts continued to make actual results nearer to the target figures.

CONCLUSION

In conclusion, it has been found that establishing production goals and carefully comparing actual results on a weekly basis has improved the operation. The entire organization is better informed because of this system and communication has been enhanced.

ACKNOWLEDGEMENTS

Thanks to South Coast Sugars, Inc. for allowing the presentation of this paper. Thanks to Peter Skinner who introduced the methods and encouraged their use.

THE ECONOMICS OF ENERGY PRODUCTION FROM SUGARCANE

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ABSTRACT

A material and energy balance computer program for a raw sugar factory has been developed. This program has been used to study the effect of cane composition on the production of electricity and ethanol.

This paper briefly describes the methods of analysis and the assumptions made. The analysis shows the effect of cane fiber and sucrose content on the total revenues of the factory. A simple economic study is used to show the probable costs of power generation as a means of supporting the price of raw sugar.

A brief description of the material and energy balance for new high fiber high sucrose cane varieties is also included.

INTRODUCTION

The use of a material and energy balance model for a raw sugar factory has been developed (3), and used to study the possible energy products available. The model has the flexibility to operate with a wide range of factory options. These options include: varying number of mills, different evaporator schemes, different boiling schemes etc.

The conditions used in this analysis are referred to no specific factory, but are close to those found in the majority of U.S. factories. The emphasis on sugar production has led to the development of high sucrose low fiber canes such that the factories are only just self sufficient in fuel. Changes in the sucrose to fiber ratio affect the overall energy and product balance and are the basis for this study.

The operation of the steam plant in the factory is critical to the production of power as an "export" product. An analysis of the operation using very high pressure steam is an integral part of the study. Assumptions concerning the unit prices for the products as well as capital costs for factory modifications are included and provide an indication of the economic viability.

Cane selection

The varieties selected for this analysis correspond closely to three types which are available commercially. Only Variety 1, however, is used as a sucrose cane (Table 1). Other varieties which have recently been developed are discussed in more detail later in this paper.

Table 1. Properties of three cane varieties used in studies.

	Variety #		
Cane properties	1	2	3
Fiber % cane	13.4	17.5	28.0
Solids % cane	16.2	11.8	11.1
Sucrose % cane	14.0	8.9	8.4
Reducing sugars % cane	0.6	1.0	1.6
Yield, tons per acre	31.5	43.0	85.0

Factory description

The model factory used in this analysis is a simulated unit which comprises the following:

1.	Milling tandem	knife set shredder five 3-roller mills
2.	Evaporators	Quad effect with 1st effect vapors to pans and juice heaters 2nd effect vapors to juice heaters
3.	Vacuum pans	Either a 3-boiling scheme or single strike only
4.	Steam production	a) 250 psig 550°F b) 850 psig 850°F
5.	Turbogenerator	Extracting/condensing units rated for specific live steam pressure
6.	Ethanol production	Distillery and stripping columns using final or high test molasses or clarified juice

Product options

The electrical power generated is solely dependent on the steam pressure and the specific factory demands based on processing operations. The processing options considered are:

a) Conventional 3-strike sugar and molasses (CS + M)

b) Conventional 3-strike sugar and ethanol (CS + E)

c) Single-strike sugar and ethanol from residual molasses and filtrate (PS+ E)

d) Ethanol only, from clarified juice (EO)

In order to provide a balanced factory, the extremely high fiber cane is milled using only three mills, thus ensuring no excess exhaust steam.

Sucrose extraction

The overall mill extraction has been determined, using an empirical formula. This formula relates the extraction to:

a) The number of mills

b) The fiber % cane

c) The imbibition rate

This expression is similar to that suggested by Hugot (2) and has been compared with experimental data obtained by Birkett et al (1). The expression is:

$$\text{Ext} = 81.5(1-F/100)^{1.428} \times (1 + I/100)^{0.68} \times (1 + .3N)^{0.212}$$

where F = Fiber % cane

I = Imbibition % cane

N = Number of mills

This equation slightly underestimates the overall Pol extraction, but does provide a good fit over the full range of fiber contents used in this study.

Factory energy requirements

The steam for the prime movers is assumed to be at 250 psig and is obtained directly from a low pressure boiler or from an extracting turbogenerator whose inlet pressure is 850 psig. The back pressure steam is used in the processing operation with any extra exhaust steam being extracted from the turbogenerator. Figure 1 shows the steam flow for a low pressure unit while Figure 2 illustrates the steam demands operating with a high pressure boiler.

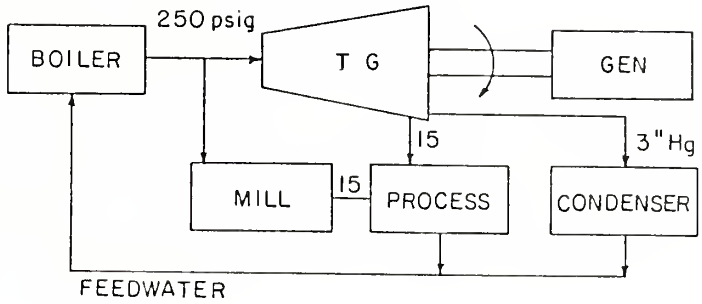

Figure 1. Low pressure system.

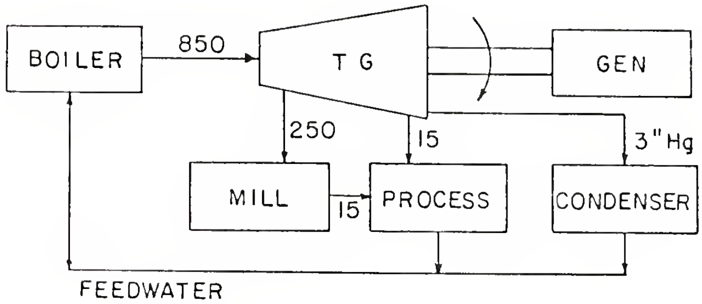

Figure 2. High pressure system.

The turbogenerators are assumed to be extracting condensing units with a back end pressure of 3" Hg absolute and an overall efficiency of 75%. The boiler efficiency has been assumed to be 65% which is readily attainable in bagasse furnaces.

Factory analysis

The throughput of the factory has been determined on the basis of tons of fiber per day and in this instance corresponds to 750 tons fiber per day. Table 2 shows lists the basic factory parameters for the three varieties considered. The steam balance of a factory is determined by the steam use for prime movers and processing and it is important to eliminate any excess process steam. Under these conditions, the imbibition is reduced as the fiber is increased and for extremely high fiber canes, the number of mills is also reduced.

Variety analysis

The steam production and use have no effect on the production of sugar and ethanol since these are solely dependent on incoming cane composition and mill extraction. Table 3 shows the sugar and ethanol production for three of the processing scenarios.

Table 2. Factory parameters for three variety studies.

Variety	TCH	# Mills	Imbib % fiber
1	225	5	150
2	180	5	100
3	110	3	100

Table 3. Sugar and ethanol production for three processing scenarios.

Variety	CS&E		PS&E		EO
	Sugar TPH	Eth GPH	Sugar TPH	Eth GPH	Eth GPH
1	24.2	1225	11.2	2407	4993
2	11.0	666	7.8	1278	2743
3	5.1	282	3.6	597	1244

Assuming reasonable values for sugar and ethanol and gross revenue on a per hour basis is shown in Table 4.

The equivalent power production data has been determined, using both 250 psig steam and 850 psig 850°F steam and is given in Table 5.

Table 4. Gross revenue per hour for sugar and ethanol.

Variety	CS&E			PS&E			EO
	Sugar1/	Eth1/	Total	Sugar	Eth	Total	Eth
	$	$	$	$	$	$	$
1	10672	1838	12510	4939	3611	8550	7490
2	4851	999	5850	3440	1917	5357	4115
3	2249	423	2072	1588	896	2483	1866

1/ $0.20/lb value of sugar

2/ $1.50/gal value of alcohol

Table 5. Equivalent power production per hour.

Variety	CS&E MWh		PS&E MWh		EO MWh	
	HP	LP	HP	LP	HP	LP
1	14.7	6.6	13.1	5.4	12.3	4.9
2	18.9	9.3	18.9	9.4	18.4	9.0
3	23.2	13.3	23.2	13.3	23.2	13.1

The data as plotted in Figure 3 shows that with fiber contents above 18%, the power production is independent of processing options, provided the factory is close to balance.

The income from power generation is dependent on the sale price of electricity and in this instance has been assumed to be $0.05/kwh. This data is shown in Table 6. The sensitivity of the overall income to market costs is of interest in this analysis since processing options are clearly predicated by revenues.

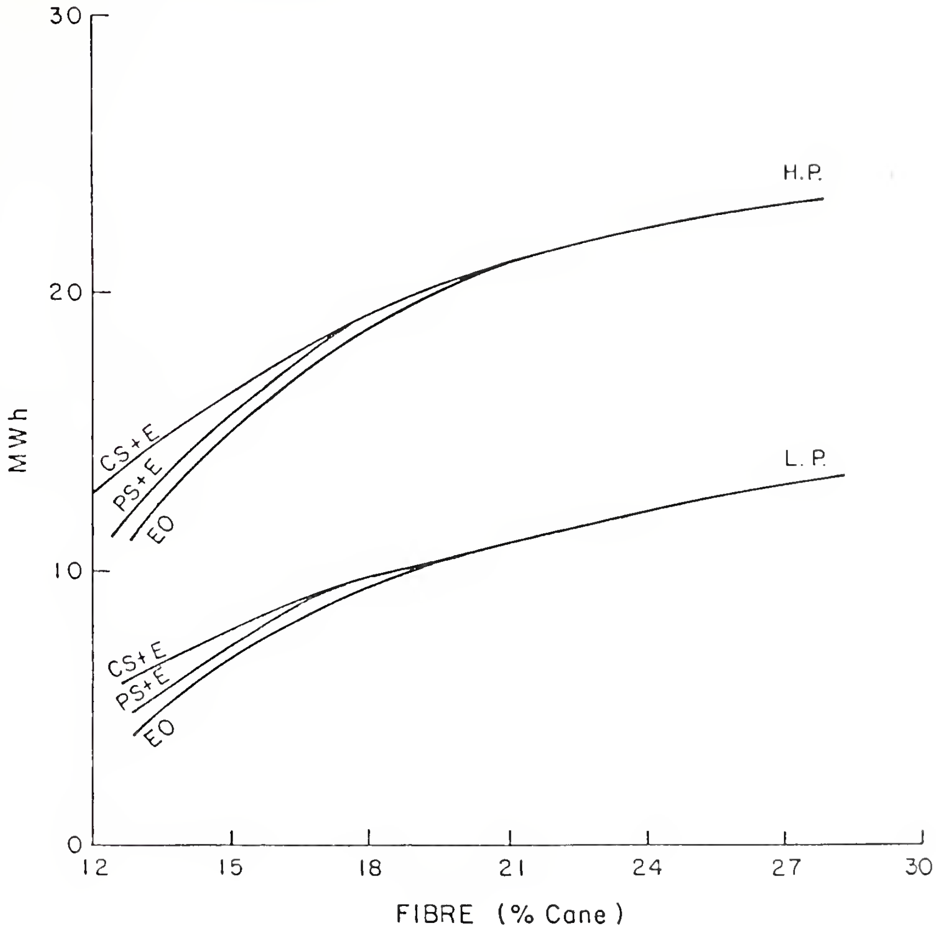

Figure 3. Effect of fibre content on electric power production.

Table 6. Income from power per hour for three varieties.

Variety	CS&E		PS&E		EO	
	HP	LP	HP	LP	HP	LP
	$	$	$	$	$	$
1	735	360	655	270	615	245
2	940	465	945	470	920	450
3	1160	665	1160	665	1160	655

The fluctuations in electric power costs are dependent on both fuel costs as well as construction costs and a reasonable range for the total awarded cost of power is 5 to 10 cents per kwh.

Figure 4 illustrates the percentage total revenue due to electrical power for high and low pressure steam generation as a function of power costs. The variation in price of sugar and ethanol will also determine the effect, on a percentage basis, of the income from electrical power, but will not alter the economics of the investment in capital equipment.

PERCENTAGE OF INCOME FROM POWER GENERATION

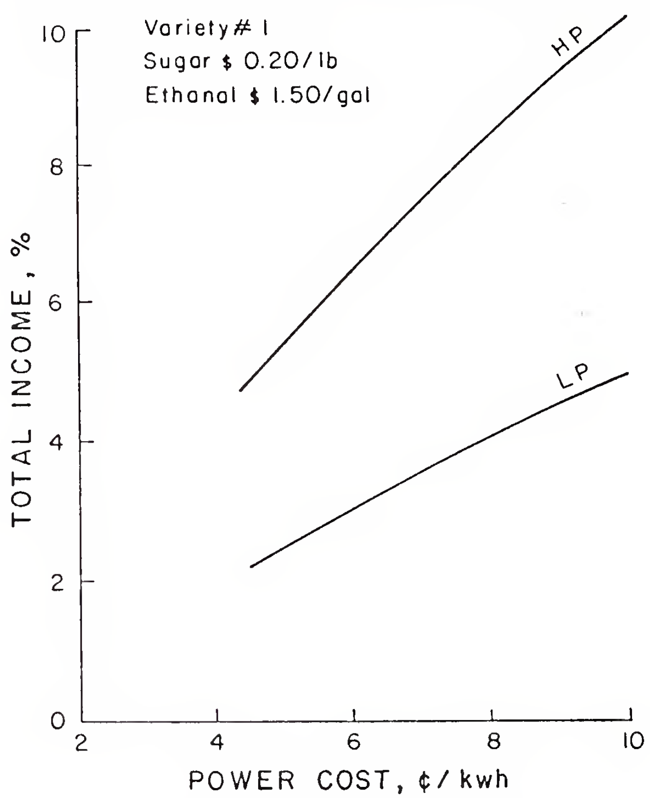

Figure 4. Percentage of income from power generation.

Economic analysis

The analysis has been carried out using Variety 1 under conditions where sugar and ethanol are produced together with electric power. The economics of ethanol production are critically dependent on the subsidies and tax incentives provided by the federal and state governments and any analysis can only be done on a specific set of conditions.

The economic benefits from electric power production are easier to ascertain and are considered below. Three methods of analyzing the economic implications are as follows:

a) Incremental income/incremental, investment

b) Energy savings analysis

c) Combination of incremental income and energy saving

For a sugar factory generating electric power, the amount which is produced will, under normal conditions, exceed internal demand. If no generating equipment previously existed, then both are energy saving and an incremental income are possible; hence, only method c above has been considered.

1. Installation of low pressure turbogenerator using existing boilers.

Table 7 shows the power production and excess power for different size factories assuming Variety 1 with complete sugar production. The cost of a 10 MWh extracting/condensing turbogenerator is of the order of $1.4 million. Assuming normal installation costs and operating expenses but with no fuel costs or depreciation, the number of weeks of operation required to repay the investment in five years at 11% interest is shown in Table 8.

Table 7. Power produced and soil from different size factories.

Grinding rate TCH	Power produced MWh	Power sold MWh
200	5.9	1.9
300	8.8	2.8
400	11.7	3.7

Table 8. Number of weeks of annual operation required to repay cost (in 5 years at 11% rate of interest) of installing turbogenerator.

Grinding rate TCH	Total income & energy saving \$ @ (5¢/kwh)	Number of weeks per year
200	49500	33
300	73900	23
400	84000	20

2. High pressure steam operation

Assuming the same factory conditions as above, the power generated and sold as a function of factory size is shown in Table 9.

The installations required in this instance are for a boiler and extracting condensing turbines. The capital investments required are different in each of these cases due to steam production changes (Table 10).

Under these conditions and with repayment periods of five years, the operating periods required per year are shown in Table 11. Clearly a 200 TCH factory cannot operate for 53 weeks per year.

Table 9. MWh produced and sold from different size factories.

Grinding rate TCH	Power produced MWh	Power sold MWh
200	13.1	8.7
300	19.6	13.0
400	26.1	17.3

Table 10. Capital investment required for different factory energy generators.

Grinding rate TCH	Boiler $\$x10^6$	Turbogenerator $\$x10^6$	Total $\$x10^6$
200	2.0	4.5	6.5
300	3.0	5.5	8.5
400	3.5	8.0	11.5

Table 11. Number of weeks of annual operation required to repay cost (in sugars at 11% rate of interest) of installing boiler and turbogenerator.

Grinding rate TCH	Number of weeks per year
200	53
300	46
400	35

Development of different cane varieties

Although extremely high fiber varieties are available in the U.S., their utilization has been limited to factory and research tests.

Development of high fiber cane in Barbados, West et al (4), has produced varieties which are significantly higher in sucrose than the equivalent U.S. canes (Table 12).

Table 12. Properties of cane varieties developed in Barbados.

Variety	Fiber % cane	Soluble solids %	Sucrose %	RS %
WI 30718	28.6	14.7	11.05	1.15
WI 80707	23.4	15.7	13.25	0.6
WI 7610	24.3	15.05	12.65	0.6
CR 3356	17.9	17.2	13.5	0.7

A brief analysis of these varieties has been carried out assuming complete sucrose production with final molasses being used for ethanol (Table 13).

Table 13. Sugar, ethanol and power produced from cane varieties developed in Barbados.

Variety	Sugar TPH	Ethanol GPH	MWH
WI 80718	7.03	318	23.9
WI 80707	12.2	203	22.2
WI 7610	11.05	246	22.1
CR 3356	17.17	522	19.6

Clearly the sucrose per hour from the factory is reduced in comparison to normal U.S. varieties, but they are significantly higher than for local high fiber varieties. The income from these varieties is shown in Table 14.

Table 14. Income comparison of products produced from Barbados and U.S. varieties.

Variety	Sugar $	Ethanol $	Power $	Value/TC $	Value/acre $
WI 80718	3100	478	1195	43.6	
WI 80707	5380	394	1110	51.6	
WI 7610	4873	370	1105	49.4	
CR 3356	7572	783	980	53.6	3323
1	10072	1838	735	58.5	1825
2	4851	999	940	38.4	1643
3	2249	423	1160	35.7	3048

The normal sucrose varieties provide a greater income from all sources, but CR 3356 offers opportunities for power generation while maintaining reasonable values per ton cane.

CONCLUSIONS

The use of differing cane varieties and investment stategies indicates that there are means by which extra income can be generated for a raw sugar house, specifically in the area of electrical power production. The development of new cane varieties with higher fiber and high sucrose content can provide a means of increasing power production and providing extra income. The larger yields of the higher fiber canes also are able to provide a higher return per acre.

The investment in power generating equipment can be a viable operation provided a reasonable price for electric power is obtained. At present costs, it would appear that the high pressure steam operation is less attractive, mainly due to the costs of new boiler equipment.

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RELATIONSHIP BETWEEN TIME-FACTOR AND SUGAR RECOVERY IN THE SUGARCANE AGRO-INDUSTRIAL PROCESS

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INTRODUCTION

The agro-industrial processes being discussed is a succession of purifications used to separate the sucrose from other components in cane juice. In every depuration, some losses occur that cannot be avoided, but frequently other losses that normally occur can be prevented.

From harvest through the various processes for raw sugar production, sugars are subjected to several harmful agents. It is necessary to not only save sucrose for commercial sugar, but the reduced sugars for final molasses. The agents are mainly acids and bacteria contained in the juice and lime, and heat that unfortunately must be applied.

The extent of damage to the sugars is proportionate to the time occurring between harvest and the manufacturing of the final products. It is felt that the importance of the time-factor is often neglected. For instance, in the recent past it was the belief of some persons that the longer the period of time between cutting and grinding the higher the sucrose content. In other words, stale cane had a higher sucrose than fresh cut cane. A portion of the increase in apparent sucrose percentage is due to the evaporation of water, but the major increase would be in the pol because of the development of dextrans.

DISCUSSION

Harvesting

As soon as cane is harvested, both chemical and bacteriological changes begin. Chemically, the sucrose is being inverted and the reducing sugars are being destroyed. Bacteriologically, the main action is the Leuconostocs producing dextran from sucrose.

Grinding

In the past, the grinding mills were operated at rather low speeds, 25-30 FPM, with a thick bagasse blanket moving slowly which permitted greater attack by bacteria. Today, the trend is toward high speeds, 80 or more FPM, with a thin bagasse blanket moving rapidly. Even though the change was made to increase mill capacity and provide for better extraction, conditions are more aseptic resulting in less chemical and bacterial action due to the time-factor.

Alkalization, heating and sedimentation..."trayless clarifiers"

There was a time when it was believed that a certain period of time was needed for the lime to react with the juice before heating. Experience has proved that what was required was improved mixing of the lime with the juice. Today that can be accomplished rapidly by mechanical means.

It is known that alkalization has to be carried out soon after the juice is extracted to avoid inversion due to the acidity of the juice, etc. But at the same time, heating has to proceed at once, because Leuconostoc develops rapidly in alkaline cold solutions. The juice must be heated to a temperature that insures a proper deaeration by flash before entering the clarifier to get rapid sedimentation.

Bear in mind that during the time of sedimentation, chemical reactions take place that result in sugar loss and if the sediments (mud) stay too long in the clarifier, bacteriological events develop at the expense of sugars.

In the past, attempts to improve quality of clarification were made by increasing the volume of the clarifiers. This resulted in longer retention time, with the consequent loss of sugars. Today, with the aid of coagulants, etc., much better equipment for control of the operations, better clarifiers, and other improvements have been made so that with the "trayless clarifiers" better clarifications can be performed in less than half the time.

Evaporation

In this step of the process the juice begins to be concentrated and with concentration the risk of sugar destruction goes up. For this reason, it becomes necessary to move the juice as fast as possible down the evaporating equipment line. Mainly, the need is to avoid retention of concentrated juice within the evaporator vessels.

In the conventional evaporator the juice coming out is really a mixture of the incoming juice and that already concentrated. A portion of the concentrated juice remains in the evaporator for an undetermined period of time. This condition does not happen in the evaporators that are referred to as "once through." An example of these evaporators is the one with a sealed downtake where no juice is retained.

Crystallization

This is the step of the process where the time-factor deserves most attention and where huge losses can occur if some principles of cane sugar technology are neglected. Due to several factors, acidity of the mother liquid, concentration, viscosity and mainly heat and time, some inversion of sucrose and decomposition of reduced sugar occurs with the formation of unfermentable compounds that affect the quality of the molasses.

For that reason the flow of the process products must be increased through the vacuum pans department, including circulation of the massecuites within the individual vacuum pan. The best circulation is obtained with mechanical circulators, but if not available the Classen Feeding is most helpful (2).

When measuring the temperature of the massecuite in a vacuum pan, an average is obtained that may be quite different from the temperature of the massecuite near the wall of the calandria tubes. The latter material must be near the temperature of the steam condensing in the other side of the tube wall.

Sometimes, because of weather or for any other reason, sugarcane has to be processed that has been infected by Leuconostoc. Then the syrup contains dextran, which increases viscosity, making crystallization of the sucrose more difficult. In this case, we can alleviate or lessen the problem by the use of surfactants.

Systems of massecuite boiling

These systems are classified mainly by the number of steps (massecuites) used to manufacture raw sugar. The ideal would be to obtain all of the recoverable sucrose in just one step, but that is Utopia. The goal has been to do the job in the least possible number of steps and to prevent excessive heat which results in the loss of sugars and caramelization of molasses.

But some times, as in the past with clarification, in attempting to produce better quality commercial sugar or obtain greater desaccharification of the molasses, the retention time has been increased and the results in these cases are contrary to what has been planned. For example, it happens when the system requires a greater number of different massecuites, the recirculation (boiling back) of products, or whenever for one reason or another, the sugars are subjected to more heat.

Two and one-half boiling system

Throughout history, the most common practice has been to make sugar in three steps, namely massecuites A, B and C, with a single magma and cooling of the C massecuite (the classical three boiling system). With the advent of the crystallization of molasses, it was possible to achieve the desaccharification in just two steps or two massecuites, namely A and C. This system worked efficiently when juice purity was low.

With new varieties of cane, etc. juices of higher purities were developed and it became necessary to boil back too much molasses to keep the proper purity gradient drop. Then the two and one-half boiling system was born as a compromise, which while maintaining rapidity in the process avoids the recirculation of molasses.

In this system the gradient of purity is carried out by controlling the purity of the intermediate massecuite that is called A-2, regardless of the purity of the A-1 massecuite. It is dependent on the purities of the syrup and the C sugar magma. The two and one-half boiling system uses a single magma procedure and both sugars, A-1 and A-2, are practically of the same excellent quality and are mixed as commercial sugar. The system is based on the two principles of crystallization on molasses and rapid cooling of the high grade massecuites.

By crystallizing on molasses, a much better form of uniform crystal is obtained that performs much better in the massecuites cooking and in the centrifugal drying and with less occlusion of impurities and less molasses film. Due to the rapid cooling of the high grade massecuite a higher purity in the A-2 massecuite is affordable with no increase in the purity of the A-2 molasses. Since the nucleation and preparation of the C massecuite footing is made with molasses and not with syrup, the A-2 molasses should not have a too low purity.

Honig (1) reported the effect of rapid cooling of a 74 purity massecuite on its crystal yield. This indicates that an important part of the desaccharification is obtained by reducing heat from the sugars instead of heating them up, as is done in the vacuum pans. Consequently, less cubic feet of massecuites are required. Another advantage of this system is that practically all of the syrup goes out directly in commercial sugar without going through the harmful process of the C massecuite.

Comparison with systems using double magma

The assumption is that the double magma system produces a better quality commercial sugar because all of it proceeds from A massecuite. Also that lower purity of final molasses can be obtained because of lower purity of the B molasses and C massecuite. As to the quality of the sugar, it can be seen that the interior of the double magma sugar crystal is formed by C sugar that was used for footing the B massecuite; B sugar makes up its intermediate layers (footing for the A massecuite) and A sugar makes up its outer layers. Therefore, in the total amount of commercial sugar these are the same components whether the sugar proceeds from the A massecuite of the double magma or from the mixing of the A and B sugar of the single magma system.

The single magma system has the advantage that in its composition there was not the recirculation of a film of B molasses covering the crystals of B sugar which was used as footing for the A massecuite, as is done in the double magma system. In the double magma system, there are two recirculations of films of molasses, one of final molasses in the footings of the B massecuite and another of B molasses when footing the A massecuite. In the single magma the only recirculation is the one in the C sugar footings of the A and B massecuites. In both systems the melting of the excess C sugar must be done in a dilutor and sent to the syrup tanks, not to the clarifier juice tank as was done before.

Besides the extra recirculation of solids, sugars and non-sugars, the double magma system requires more cubic feet of A and B massecuites combined per ton of cane processed; meaning more vacuum pans and centrifugals are needed for these massecuites, and more heat must be applied to their sugars.

It is recognized that in comparing the efficiency between the processors or sugar factories, the purity of the final molasses is not nearly as important as several other factors such as the invert-ash ratio and the conditions or quality of the cane being processed. Furthermore, when comparing final molasses purity, one needs to remember that sucrose that has been inverted, and invert sugars that have been destroyed during massecuite boiling, which can easily happen when dealing with massecuites of too high degree Brix or too low purity, will not show up in the routine analysis run in the laboratories. However, one might suspect such has happened because of the color of the sugar and of the final molasses.

Finally, when practicing double-magma systems, it is easy to end up making a "four massecuite boiling system." This system was used about half a century ago, and was abandoned because of the large amount of massecuites that was required and which resulted in an increase in the color of the sugars, and caramelization of the molasses.

With the introduction of the rapid cooling of the high grade massecuites, and the crystallization out of molasses instead of syrup, the inconveniences of the "four massecuite boilings" were no longer necessary.

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REPLANTING STRATEGY ANALYSIS TO MINIMIZE DAMAGE FROM NEW PESTS: A MICROCOMPUTER APPLICATION

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Sugarcane producers face the decision of how to allocate their land among the different available cultivars. Since in most producing areas there are usually one or two outstanding cultivars, threats of new pests make producers reluctant to rely exclusively on those cultivars. Recent research, however, has shown that fear to be unfounded under certain conditions.

This software presents a general framework for evaluating alternative cultivar replanting strategies to minimize yield damage from new pests. Users are requested to enter data such as average yield of the four most widely used cultivars over a 3-year cycle, year in which the pest arrives, projected damage caused to susceptible cultivars and land distribution among the cultivars. After completing the analysis, input variables can be changed to determine their effect on the total yield over a 20-year period and on the annual yield per acre.

Although the program uses the concept of standard ton as the yield measure, relative percentages, net tons or other units can be substituted without altering the program.

THE ASSOCIATION OF ESTIMATED YIELD POTENTIAL WITH MEASURED SUGARCANE YIELD IN INFIELD VARIETY TRIALS

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Before an experimental sugarcane variety is to be planted in Louisiana outfield variety trials, it must be planted in its respective infield for four years. Varietal yields in these infield tests are measured for the plant cane, first and second stubble crops. In the late spring and summer of the first and second stubble crop years, the yield potential of each variety is rated independently by at least ten professional agronomists. A committee composed of personnel from the American Sugar Cane League, the Louisiana Agricultural Experiment Station, and the U. S. Department of Agriculture may use these ratings of yield potential in deciding which experimental varieties will remain in active testing and which will be discarded.

This study was undertaken to determine the degree of association of rated yield potential in late spring and late summer with actual yield measured during the harvest season. Contrasting sets of comparisons were used to gain insight regarding factors that influence the effectiveness of using ratings to estimate yield potential. Factors considered included: year, crop, season, number of varieties in the test, number of rows per plot, and individual raters.

The association between rated yield potential and yield measured at harvest was significantly affected by the year, the number of varieties in the test, the number of rows per plot, and the individual doing the rating. There was a consistant year interaction with all the other factors that affected the association. The lack of consistant agreement suggests that errors associated with both estimating yield potential by rating and measuring yield need further investigation.

SUGAR YIELDS INCREASED BY WATER MANAGEMENT

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A water management system, installed in Assumption Parish, Louisiana in 1983 was effective in increasing sugar yields in 1984 and 1985. The 17-acre water management system consisted of a network of underground drains that emptied into three sumps equipped to pump drain outflow into surface drainage ditches during rainy, wet conditions. Irrigation wells, one for each sump, were installed and equipped to pump water into the sumps and throughout the subsurface drain network to provide subirrigation during droughts. The pumps for drainage and irrigation were controlled by switches activated by water levels in the sumps. During 1984, the system was used only in the subsurface drainage mode. In 1985, the system was used in the drainage mode during the winter and early spring months when the water table was high, then switched to the subirrigation mode in the summer during a drought. In the subirrigation mode, the irrigation water added to the sump caused the water table to rise into the cane's root zone for short durations, just long enough to replenish the soil water that had been used by the cane plants or lost to evaporation. A 17-acre field adjacent to the water management system without subsurface drainage and irrigation was used as a check.

In 1984, when subsurface drainage only was used, the sugar yield of 7,224 lbs/A from drained area was 738 lbs/A more than that from the nondrained area. In 1985 when both drainage and irrigation were used, the sugar yield of 6,543 lbs/A from the water management area was 1,469 lbs/A more than that from the area without water management. Thus, water management increased sugar yields 11 percent and 29 percent on plant (1984) and first ratoon (1985) crops, respectively. This experiment was on Commerce silt loam soil and the sugarcane variety was CP 70-321.

SEASONAL PHENOLOGY OF WHITE GRUBS (COLEOPTERA: SCARABAEIDAE) IN FLORIDA SUGARCANE FIELDS

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The seasonal phenology of two white grub species found in Florida sugarcane was determined under field conditions. Pupation, adult emergence, oviposition, and egg hatch occurred from April through June in *Cyclocephala parallela* Casey and April through July in *Ligyrus subtropicus* Blatchley. The third instar larva was the longest-enduring and overwintering stage in both species. Both grub species had a 1-year life cycle under field conditions. The major difference between the seasonal phenologies of the two grub species was that developmental stages of *C. parallela* preceded corresponding developmental stages of *L. subtropicus* by 2-6 weeks at peak abundance. The relationship of these preceding data to grub damage in Florida sugarcane is discussed.

DISTRIBUTION OF DENSITY ESTIMATES FOR POPULATIONS OF *CLAVIBACTER XYLI* SUBSP. *XYLI* IN SAP SAMPLES FROM SUGARCANE

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The extent to which *C. x.* subsp. *xyli*, the bacterium that causes ratoon stunting disease, multiplies in different sugarcane cultivars is inversely correlated to the degree of resistance of the cultivars to the disease. In order to obtain more

accurate estimates of the population densities of the bacterium in different cultivars and to effectively analyze variation among these densities, the distribution of density estimates within 71 data sets was examined. A data set consisted of individual estimates from 8 to 30 stalks of a cultivar sampled within one time period and location. Eleven infected cultivars grown at two locations were sampled at various times. Density estimates were obtained by enumerating C. x. subsp. xyli in sap samples from stalk internodes using a fluorescent-antibody direct-count technique. The estimates were not normally distributed about the arithmetic mean in the majority of the data sets. Additionally, there was a positive relationship between the means and variances for the data sets. An exponential transformation, whereby indivdual density estimates were raised to the 0.25 power, was found to normalize most of the distributions and eliminate the relationship between means and variances. This data transformation permits the effective use of parametric statistics in the analysis of variance among population densities.

EFFICACY OF AERIAL APPLICATION OF A 2 PERCENT ZINC PHOSPHIDE BAIT ON COTTON RATS (SIGMODON HISPIDUS) IN FLORIDA SUGARCANE

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Six fields varying from 29 to 47 acres in the Rutledge section and two 40-acre fields in the Valentine section of New Hope Sugar Corporation were selected for study. A minimum of four cotton rats per 20 traps had to be captured before a field was accepted as a test field. A total of 12 fields were sampled to find 8 fields that met this criteria. The fields sampled were selected to ensure that they were separated from each other by a natural barrier, such as a canal, or were at least one full field (36 acres) apart.

The initial sampling with live traps occurred on August 9-16, 1985. The zinc phosphide bait was aerially applied by helicopter on August 16, 1985 to the designated treated fields and buffer areas around each treated field. Buffer areas were approximately a half field (600 feet) on all sides of the treated field.

Forty Victor snap traps were placed at 30-feet intervals on two transects in each half-field test area on August 24, 1985. One transect was three sugarcane rows inward from the field edge and the other transect was through the middle of the field. The snap traps were baited with small (one-half inch) slices of apple which were changed daily. The fields were sampled from August 26-31, 1985.

A total of 295 cotton rats, 4 black rats and 3 field mice were trapped over the 5-day trapping period. The cotton rat populations in the control and baited fields were found to be significantly different from each other, using Duncan's Multiple Range Test (alpha=0.05). The populations of black rats and field mice were also found to be significantly different from each other in the baited and control fields using Duncan's Multiple Range Test, but the populations were too low to be meaningful.

MINIMUM TILLAGE APPROACHES TO SUGARCANE PLANTING

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Several concepts for planting sugarcane were examined during a 2-year study. Planting techniques included planting an erect cultivar with a recumbent cultivar to improve crop erectness, planting sugarcane in row middles to achieve 30-inch rows, planting sugarcane into sod killed with a herbicide, and planting sugarcane in row middles after the old stubble was killed with a herbicide. Some concepts have been discarded and others are being examined in more detail. Good tonnage yields were obtained when sugarcane was planted into sod killed with a herbicide. Plantings which resulted in 30-inch rows did not produce yield increases which justified the effort. Mixing of cultivars to reduce lodging did not appear effective, as the recumbent cultivar lodged as normal. Minimum tillage planting techniques produced good tonnage yields, and a new trial has been initiated.

USE OF NIR SPECTROSCOPY FOR THE ANALYSIS OF SUGARCANE QUALITY

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NIR (Near Infrared) reflectance spectroscopy was compared to the standard press method for determining fiber, sugar, moisture percent cane, and pol percent juice for sugarcane samples. Whole stalks of cane were chipped with a knife mill. The shredded samples were divided into two subsamples. The standard press analysis was performed on one subsample. The second subsample was divided into four replicates upon which NIR analysis was performed. The optical density (OD=log(1/R) where R is the reflectance) was measured from 1100 to 2500 nm at every 2 nm. The instrument software was used to generate the second derivative of the OD. Then based on the second derivative of the OD the calibration equation for each quality parameter was obtained with four wavelengths.

Calibration correlations found for these wavelength sets were 0.991, 0.910, 0.987, and 0.989, respectively, for pol, fiber, sugar, and moisture content of the sugarcane sample. The values of these quality parameters estimated by the NIR method were compared to the values estimated by the standard press technique. There was no statistical difference between the estimates from the standard press technique and from the NIR method for pol, fiber, sugar, and moisture values. Correlations between the two methods were 0.957, 0.834, 0.956, and 0.957 for pol, fiber, sugar, and moisture, respectively. These results suggest that accurate estimates of cane quality can be achieved with this new method. Because chipping is the only sample preparation, considerable time could be saved by using NIR to analyze sugarcane quality.

ANALYSIS OF PRODUCTION DATA OF SUGARCANE GROWERS AND PROCESSORS

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A standard practice of commercial enterprises is to make decisions about production methods (treatments) based on analysis of the mean outputs of these treatments. Due to the varying environments under which sugarcane is grown, and the potentially large effects that environments can have on treatments, it has been shown that a previously described method of stability analysis can provide a more complete analysis of treatments than does use of their overall mean outputs. For sugarcane growers, the technique could be a useful tool to analyze differences among such cultural practices as cultivars, ripeners, or fertilizers. For sugarcane processors, it is not certain if stability analysis would be as useful. If large differences among treatments do exist across environments, then the technique could be useful. Otherwise, sugarcane processors may wish to use simple regression analysis rather than overall means. Examples of situations where stability analysis could be tried would be in testing different methods of controlling sugar grain size, adjusting boiler plant efficiency, drying bagasse, or in testing the fuel efficiency of bagasse at various moisture levels. For enterprises using computers, daily data collection and storage would not be limiting factors in using the suggested analyses. Calculations for the analyses could be done with inexpensive software that is available for most computer systems. With either stability or regression analysis, results can be displayed in a graphic format that can improve the decision-making process.

RATOON STUNTING DISEASE: PATTERNS OF COLONIZATION OF VASCULAR TISSUES BY CLAVIBACTER XYLI SUBSP. XYLI IN SUGARCANE CULTIVARS

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A modified immune-blot assay was used to detect and enumerate vascular bundles containing Clavibacter xyli subsp. xyli in internode tissues of mature stalks from diseased sugarcane cultivars CP 72-1210, CP 44-101 and CP 70-1133 which are susceptible, intermediate and resistant, respectively, to ratoon stunting disease. Two or three stalks from five plants of each cultivar were examined at each sampling date. The proportion of infected vascular bundles differed significantly between cultivars. Substantially less infected vascular tissue was detected at each sampling location on stalks of CP 70-1133 as compared to CP 44-101 and CP 72-1210. In all cultivars, the proportion of infected vascular tissue progressively declined with increasing sampling distance from the base of each stalk. A highly significant correlation ($r=0.974$; null hypothesis: slope=0, $P=0.0001$) was found between the proportion of infected vascular bundles and populations of C. x. subsp. xyli in sap extracts from corresponding internode tissues. The ratio of bacterial populations to infected vascular bundles was similar for each cultivar at all sampling locations on stalks.

USE OF NEUTRON SCATTERING FOR MOISTURE DETERMINATION IN SAND SOILS

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Neutron probes have been used for irrigation and drainage scheduling in many areas of the U.S. for years, although their use in the sugarcane industry of South Florida is limited. Other instruments to determine soil moisture content such as tensiometers and psycrometers are of limited value in sand soils because of their limited detection range. Additionally, water balance equations are not very suitable due to difficulty in accounting for percolation losses and sub-irrigation gains in the soil profile. Neutron scattering was found to be highly correlated to volumetric water content in the rooting zone of six test sites in sand soils. With proper field calibration, neutron scattering can be a rapid and reliable tool for soil moisture determination.

YELLOW SPOT DISEASE OF SUGARCANE IN THE UNITED STATES

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Yellow spot disease of sugarcane, caused by the fungus Mycovellosiella koepkei (Kruger) Deighton, was found for the first time in the United States in October of 1985. The disease was first found in a 3.8 ac planting of CL 72-895, an unreleased variety in the United States Sugar Corporation (USSC) breeding and selection program. Symptoms of the disease were first evident on the young leaves as small oval, ellipsoidal, or irregular yellow spots which were distributed over all portions of the leaf blades. As the leaves matured, the spots enlarged and ranged in size from very small to 1-2 cm in diameter. The spots were irregular in shape and remained as discrete entities or coalesced to cover large areas of the leaf. A dirty-grey fungal growth, consisting largely of conidiophores and conidia, was often seen on the lower surface of infected leaves. To date in Florida, yellow spot has been observed in six varieties. Of these, four are unreleased or recently released varieties in the USSC varietal development program and occupy only a small area. The other two varieties, CL 59-1052 and CL 68-575, are commercial varieties and collectively occupy approximately 8.4 percent of the acreage in Florida. As of December 1985, yellow spot has been found east and south of Lake Okeechobee from Canal Point to Lake Harbor, Florida. Due to the losses attributed to yellow spot in other countries and the moderate susceptibility of a major commercial variety, the disease must be regarded as a potential problem to the Florida industry.

THE EFFECTS OF YEARS AND LOCATIONS ON THE REPEATABILITIES OF SUGARCANE YIELD COMPONENTS IN LOUISIANA

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Fifty-four Louisiana sugarcane varieties were planted in 1983 and 1984 at five locations. Variance components were obtained for the plant cane crop and used to calculate repeatabilities between years and between locations for tons of cane per hectare, grams of sugar per kg cane, tons of sugar per hectare, height, stalk number, cane diameter, brix and sucrose percent. Repeatabilities less than unity demonstrated the diminishing effect genotype by year and genotype by location interaction had on respective selection over locations within a year and selection over years within a location. Mean genotypic yields together with the percent of environments in which a genotype did not yield significantly less than the best genotype in that environment, were shown to easily delineate the most promising genotypes. Since most analyses are performed on a single year basis, the genotype by location mean square is used to test genotypic means. LSDs calculated as a function of the number of locations, replications, and genotypes, showed increasing the number of locations and/or replications substantially increases the power of the test. Comparisons of increase in power with the number of locations and the number of replicates suggest that the optimum number of locations is seven and the optimum number of replicates is four.

SYNCHRONIZATION OF FLOWERING IN THE LSU SUGARCANE BREEDING PROGRAM

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Natural flowering of commercial sugarcane varieties in Louisiana sugarcane fields rarely occurs. The discovery of photoperiod induction of flowering in sugarcane enabled the LSU sugarcane breeding program to expand in the early 1950s. While techniques in the production of viable seed have been greatly improved, the synchronization of flowering among all varieties in the program has been due to a universal sugarcane breeding problem.

Studies conducted in the LSU sugarcane breeding program during the 1981, and 1983 through 1985 crossing seasons have led to excellent synchronization of flowering among the array of varieties used in the program. The standard 12-hour and 30-minute induction photoperiod, followed by a photoperiod decreased at a rate of one minute per day, was used to control flowering. Using records of the number of days from the beginning of the photoperiod treatment to the emergence of the tassel, each variety was categorized by its flowering response to photoperiod treatment. In 1984 and 1985 varieties were subjected to photoperiod treatment durations dictated by their flowering categories. Photoperiod treatment based on varietal flowering response has resulted in excellent synchronization of tasselling among the varieties used in the program. Consequently, synchronization of flowering is no longer an obstacle to the production of desirable crosses in the LSU sugarcane breeding programs.

PROTECTION OF SUGARCANE STUBBLES FROM FREEZE DAMAGE IN LOUISIANA

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Experiments have been conducted to determine the effects of protecting cane stubbles from freeze damage during the winter months on the yield of sugarcane. The protection treatment consisted of covering the stubbles with approximately three inches of soil with a disk cultivator after harvesting a crop and removing the soil cover with a stubble shaver in early spring. The treatment was tested with cane varieties CP 65-357 and CP 72-370 after harvesting plant cane on three dates in one experiment and after harvesting first, second and third stubble cane from planting in different planting furrow widths in another experiment.

Average results for three years show that the protection treatment applied after harvesting plant cane in September, October and November increased the first stubble cane yields 14.6, 11.4 and 16.9 percent with CP 65-357 and 14.1, 12.3 and 22.7 percent with CP 72-370, respectively. As an average of both varieties, the treatment increased yields of second, third and fourth stubble cane 15.0, 18.0, 22.5 and 28.0 percent with planting widths of V, 18, 24 and 36 inches, respectively. Results indicate that freeze damage to overwintering cane stubbles is dependent apparently on the variety of cane, date of harvest, width of planting and the severity of freezing temperature.

EVALUATION OF ETHEPHON IN CONTROLLING SUGARCANE FLOWERING IN FLORIDA

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In Florida, many varieties flower early in the harvest season, causing reduced yield due to the development of pith in the upper section of the stalks. A 3-year study involving small plots and commercial fields has shown that ethephon applied in early September reduced flowering. Approximately 24 inches of pith was observed in flowering stalks, but no pith was found in nonflowering stalks. Although upper sections of nonflowering stalks were heavier and produced more juice than similar sections of flowering stalks, this did not always result in increased yields of cane and sugar at harvest. When harvest was greatly delayed following freezing temperatures, an unknown amount of pith-free top section was lost due to the necessity of discarding the decomposed freeze-damaged tops. The results indicated that ethephon can be beneficial on early, heavily flowering varieties if harvesting can be scheduled before the stalks begin to deteriorate after freezes.

CONVERTING THEORY INTO PRACTICAL USES: A REVIEW OF USDA'S NARROW-ROW SUGARCANE RESEARCH AT HOUMA, LOUISIANA

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Research conducted at the Houma Laboratory from 1967 to 1976 indicated that narrower inter-row spacings increased populations of millable stalks and yields. These studies were conducted on small, hand harvested plots planted on level ground. Since 1976, large plot experiments have been planted on raised beds to determine the feasibility of culturing sugarcane at inter-row spacings of 0.9 and 1.2 m as compared to the conventional 1.8 m spacing under Louisiana conditions where a short-season, erect crop adaptable to mechanical culture and harvesting is required. Yield response to fertilization rates, cultivation frequencies and distances, and weed competition were also evaluated. Although significant increases in yield of cane and sugar were obtained in the plant cane crop at the narrower row spacings, this increase was not maintained in the ratoon crops. The major contributing factors to the narrower row yield declines were stubble piece destruction during the harvesting operation and reductions in winter survival resulting from rutting during wet-weather harvest. Fertilization experiments have shown that 168 kg N/ha was sufficient for CP 72-370 at all row spacings on Sharkey clay. Cultivation studies indicated that root pruning associated with frequent cultivations of the narrower rows did not adversely affect yield, even though sugar cane roots were closer to the soil surface in the narrower row spacings. Frequent cultivation at these spacings could become a significant factor in reducing herbicide usage in a weed management program. Multi-row equipment for planting, fertilizing, cultivating, harvesting, and hauling that have evolved during the past five years of these studies will also be discussed. This equipment approaches the efficiency of the commercially developed equipment for 1.8 m rows and should allow more meaningful yield comparisons in future row spacing research, particularly in the ratoon crops.

PUBESCENCE AS A PLANT RESISTANCE CHARACTER AFFECTING OVIPOSITION BY THE SUGARCANE BORER

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Pubescence is a plant characteristic that has often been associated with resistance to insect pests. Pubescent varieties of potatoes have been found to be resistant to aphids and leaf hoppers, resistant to white flies and flea beetles in tomatoes, to the alfalfa weevil in alfalfa, to the cereal leaf beetle in wheat, and to the yellow sugarcane aphid in sorghum to name a few.

Leaf hairs were discovered in a clone of Saccharum robustum. In free choice and no-choice experiments, the sugarcane borer laid significantly fewer eggs on pubescent leaves than on smooth leaves. On the other hand, borers laid significantly more egg masses on hairy leaves than on smooth leaves. However, the egg masses laid on pubescent leaves contained significantly fewer eggs per egg mass than on smooth leaves. Pubescence could be an important plant defense mechanism providing resistance in sugarcane against the sugarcane borer and possibly other pests of sugarcane.

COLD TOLERANCE AMONG SUGARCANE CLONES IN STAGE II

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A population of 845 experimental clones (CP 84-Series) of the Stage II test and four check varieties were examined for their resistance to cold injury following freezes in December 1985 and January 1986. The buds in the middle section of the stalks of most clones were destroyed by the freezing temperatures, but some buds that were covered by the green leaf sheaths at the top of the stalks appeared to be undamaged. Stalks still with viable buds on the top section were counted approximately two months after the last freeze, when most of the buds had germinated to produce shoots. Three 5-stalk samples from each of 16 superior cold-tolerant clones plus four check varieties were collected and milled. Crusher juice was analyzed for Brix, sucrose, purity and sugar per tonne of cane. Data on the percentage of stalks with viable buds indicated that the frequency of sugarcane clones with superior cold tolerance was low. Those clones with high percentage of stalks with viable buds appeared to have erect or semi-erect stalks and suffered slight or no tissue injury and may have received some protection from foliage cover during the relatively short duration of freezing temperatures. Among four checks examined, the percentage of stalks with viable buds in the top section for CP 70-1133, CP 65-357, CP 72-1210, and CP 57-603 were 2.47 percent, 27.17 percent, 33.80 percent, and 42.23 percent, respectively. The 16 experimental clones with a high percentage of viable buds had better juice quality than did CP 70-1133, which was the poorest among four checks, two months after the last freeze. However, only one experimental clone, CP 84-1089, had juice quality that exceeded that of the best check variety, CP 72-1210.

ABSTRACTS - MANUFACTURING

LOUISIANA MOLASSES

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The diversity of uses of final molasses, e.g. in blends for human consumption, as a fermentation feedstock and as animal feed, requires varying specifications for the molasses. These involve analyses which are not standard procedure for a sugar mill laboratory, e.g. color and suspended solids for direct-consumption blends, non-fermentable reducing substances for alcohol production and gelling of molasses in animal feed production. Data will be presented on these and other parameters measured in a study designed to more completely characterize Louisiana molasses.

DEXTRANASE AND THE U.S. SUGAR INDUSTRY - PROBLEMS AND POTENTIALS

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Dextran control is a problem of growing economic importance to the raw sugar producer. One approach that has been successfully applied in other parts of the world is the addition of the enzyme dextranase to a process stream.

A comparison of the various commercially available dextranases, their usage and their regulatory status will be presented. The potential of a new dextranase preparation recently developed at the Audubon Sugar Institute will also be described.

MIXING TECHNOLOGY FOR THE SUGAR INDUSTRY

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Due to the sugar industry's difficult market situation, production costs must be as low as possible. One efficient way to contribute to low production costs is to use optimally-designed mixing equipment.

In each process stage of the sugar mill requiring agitators, the flow field produced by the impeller has an enormous effect on the efficiency of the process. This effects the economics of the entire plant. Therefore, the correct selection and design of mixing equipment provides lower production costs and increased profitability.

The optimum agitator design for each process step is the result of many years of experience and continuous development. The behavior of different mixing systems, like vacuum pans with circulators, stirred columns with multi-stage impellers or pipelines with flowmixers, have been studied extensively. These studies have been done under vastly different operating conditions, with both Newtonian and non-Newtonian fluids. The knowledge gained has been used with success in the optimal design of agitators for each process step in a sugar plant that requires agitation.

SUBMERSIBLE ARC WELDING MILL ROLL SHAFTS

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Submersible welding is new to the sugar industry, although it has been used in the ship-building industry for a few years. Previously, metalizing of mill journals was the only way to repair worn mill roll journals. Metalizing can be

an effective process if the finished product is handled carefully, but when a mill roll is being reshelled or is in the lathe for grooving, it is easy to damage the metalized journal. In 1983, a journal that had been metalized came apart during the harvest season. This prompted study of the Sub-Arc process (A.B.S. approved), then being used successfully in marine and ship building shops.

The advantage of the Sub-Arc process is that it can be done by the factory itself and does not require special equipment. Sub-Arc will not be harmed when run in a steady rest of a lathe, since it is a process that has been welded on and not sprayed on like a sleeve. Sub-Arc welding is more durable and will not come off the shaft like metalizing. Its cost is comparable to metalizing, although Sub-Arc welding can be done by in-shop personnel.

DIRECT DETERMINATION OF PHOSPHORUS LEVELS IN MOLASSES SAMPLES BY INDUCTIVELY COUPLED PLASMA

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A new procedure for determining phosphorus levels in molasses samples without prior digestion was compared to the double acid, molydate blue procedure. The direct digestion method is a rapid procedure that required dilution in 0.1 N HCl then direct injection into an inductively coupled plasma torch. The direct method had a slope of 1.01 when regressed against the double acid method (r^2=.99).

STORING WHITE SUGAR IN BULK

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This paper describes the theory of white sugar preservation, including the desorption curve, the effects of maturation, and the effects of temperature. Conditions necessary for perfect storage of white sugar such as hermetical sealing, air sugar equilibrium, heat insulation, and automatic operations are discussed. The safety of storing white sugar in silos in regard to both the origin and protection from explosions are detailed.

AUTOMATED FLOCCULANT PREPARATION

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Proper flocculant preparation can result in much increased flocculant efficiency. For the 1985/1986 season, Atlantic Sugar Association installed an automatic juice flocculant prepartion unit. Flocculant usage was reduced by almost 30 percent in comparison with the previous season. Operating experience and results are discussed.

DETERMINATION OF DEXTRAN AND OTHER HIGH MOLECULAR WEIGHT SUBSTANCES IN SUGARCANE FACTORY PRODUCTS BY GEL PERMEATION CHROMATOGRAPHY

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The total content of high molecular weight (HMW) substances was determined in a number of samples collected in a sugarcane factory during the 1985 season. Initially, the HMW substances were concentrated using a hollow fiber ultrafiltration system and then separated from the low molecular weight fraction on a series of GPC columns equipped with an RI detector. The samples were also analyzed for dextran using the ASI II dextranase-based method, and the results were correlated with the GPC determinations.

A NEW TARGET PURITY CURVE

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A new target purity curve has been developed for evaluating molasses exhaustion in U.S. Mainland factories. The curve, the equation of which is:

$$\text{Target True Purity} = 42.8 - 13 \log (\text{Red. Sugar/Ash})$$

was arrived at independently by both empirical and theoretical approaches. The empirical line was set by inspection of all the exhaustion data obtained from molasses survey samples drawn over the last five years. The line was placed at levels reached in practice only 5 percent of the time. Plant purities exceeded the line 95 percent of the time. Thus, the new line gives a practical target for U.S. factories - it gives purities which demonstrably <u>can</u> be achieved but, in fact, rarely are.

The theoretical approach combined measured solubilities, viscosity data from the literature, and a mathematical model to generate a target purity equation. It coincided with the empirical line described above.

AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS
EDITORIAL POLICY

Nature of papers to be published:

Papers submitted must represent a significant technological or scientific contribution. Papers will be limited to the production and processing of sugarcane, or to subjects logically related. Authors may submit papers that represent a review, a new approach to field or factory problems, or new knowledge gained through experimentation. Papers promoting machinery or commercial products will not be acceptable.

Frequency of publication:

The Journal will appear at least once a year. At the direction of the Joint Executive Committee, the Journal may appear more frequently. Contributed papers not presented at a meeting may be reviewed, edited, and published if the editorial criteria are met.

Editorial Committee:

The Editorial Committee shall be composed of the managing editor, technical editor for the Agricultural Section and technical editor for the Processing Section.

The Editorial Committee shall regulate the Journal content and assure its quality. They are charged with the authority necessary to achieve these goals. The Editorial Committee shall determine broad policy. Each editor will serve for three years; he may at the Joint Executive Committee's discretion, serve beyond the expiration of his term.

Handling of manuscripts:

Four copies of each manuscript are submitted to the managing editor. Manuscripts received by the managing editor will be assigned a registration number determined serially by the date of receipt. The managing editor writes to the one who submitted the paper to inform the author of the receipt of the paper, the registration number which must be used in all correspondence regarding it, and the page cost of publishing.

The technical editor receives from the managing editor all papers whose subject matter falls in his "area." He obtains at least two reviews for each paper from qualified persons. The identities of reviewers must not be revealed to each other nor to the author during the review process. Instructions sent with the papers emphasize the necessity for promptness as well as thoroughness in making the review. Page charges will be assessed for the entire manuscript for non-members. Members will be assessed for those pages in excess of ten (10) double spaced pica typed pages of 8½" x 11" dimension with one (1) inch margins.

When a paper is returned by a reviewer, the technical editor evaluates the paper and the recommendations of the reviewers. If the paper as received is recommended by two reviewers for publication in the Journal, it is sent to the managing editor.

If major revisions are recommended, the technical editor sends the paper to the author for this purpose, along with anonymous copies of reviewers' recommendations. When the paper is returned to the technical editor, he will judge the adequacy of the revision and should send the paper back to any reviewer who requested major changes, for his further review. When the paper has been revised satisfactorily, it is sent to the managing editor for publishing. A paper sent to its author for revision and held more than 6 months will be given a new date of receipt when returned. This date will determine the priority of publication of the paper.

A paper rejected by one reviewer may be sent to additional reviewers until two reviewers either accept or reject the paper.

If a paper is judged by two or more reviewers as not acceptable for the Journal, the technical editor returns it to the author along with a summary of the reasons given by the reviewers for the rejection. The registration form for the paper is filled out and returned to the managing editor along with copies of the reviewers' statements and a copy of the technical editor's transmittal letter to the author. The reviewers' statements should not be forwarded to the author in this instance.

The names of all reviewers must be shown on the registration form.

After the review process is completed, each accepted paper is read by the technical editor to correct typographical, grammatical, and style errors and to improve the writing where this seems possible and appropriate, with special care not to change the meaning. Instructions for the printer are inserted as needed. The papers are sent by the technical editor to the managing editor who notifies the authors of this fact and of the probable dates of publication.

Preparation of papers for publication:

Papers sent by the technical editor to the managing editor are prepared for printing according to their dates of original submittal and final approval and according to the space available in the next issue of the Journal.

Tables are retyped in the proper form for reproduction, and proofs are sent to the authors along with the galley proofs. When the proofs are returned, all necessary corrections are made prior to reproduction.

The drawings and photographs for the figures in the paper are "scaled" according to their dimensions, the size of lettering, and other factors. They are then sent to the printer for camera work. Proofs of the illustrations are sent to the authors. Any changes requested at this stage would be expensive and authors will be expected to pay the cost of such changes.

The author will be notified at the appropriate time that he may order reprints at cost.

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RULES FOR PREPARING PAPERS TO BE PRINTED IN THE JOURNAL OF THE AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS

Format

Unless the nature of the manuscript prevents, it should include the folloing sections in the order listed: ABSTRACT, INTRODUCTION, MATERIALS and METHODS, RESULTS, DISCUSSION, CONCLUSIONS, ACKNOWLEDGMENTS, and REFERENCES. Not all the sections listed above will be included in each paper, but each section should have an appropriate heading that is centered on the page with all letters capitalized.

Authorship

Name of the author(s), institution or organization with which he is associated, and the location should follow the title of the paper.

Abstract

The abstract should be placed at the beginning of the manuscript, immediately following the author's name, organization and location.

Tables

Number the tables consecutively and refer to them in the text as Table 1, Table 2, etc. Each table must have a heading or caption. Capitalize only the initial word and proper names in table headings. Headings and text of tables should be single spaced. Each table should be on a separate sheet.

Drawings & Photographs

Drawings and photographs must be provided separately from the text of the manuscript. Type figure numbers and legends on separate pieces of paper with proper identification. Drawings and photographs should be of sufficient quality that they will reproduce legibly.

Reference Citations

The heading for the literature cited should be REFERENCES. References should be arranged such that the literature cited will be numbered consecutively and placed in alphabetical order according to the surname of the senior author. In the text, references to literature cited can be made by number or name of author and number from list of references. (See example.) Do not use capital letters in the titles of such articles except in initial words and proper names, but capitalize words in the titles of the periodicals or books.

Suggested Format (Examples below)

EVALUATION OF SUGARCANE CHARACTERISTICS
FOR MECHANICAL HARVESTING IN FLORIDA

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Agricultural Engineers, SEA, USDA, Belle Glade, Florida

J. D. Miller and P. Tai
Research Geneticists, SEA, USDA, and Canal Point, Florida

ABSTRACT

INTRODUCTION

MATERIALS and METHODS

RESULTS

Table 1. Varietal characteristics of nine varieties of sugarcane over three-year period at Belle Glade, Florida.

Figure 1. Relative size of membrance pores.

DISCUSSION

CONCLUSIONS

ACKNOWLEDGMENTS

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AUTHOR INDEX